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IN THEIR APPLICATION TO

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THE CHEMICAL NEWS.

VOLUME CXXII.

EDITED BY JAMES H. GARDINER, F.C.S.

No. 3169.—JANUARY 7, 1921.

EDITORIAL.

ONE of the many revelations of the war has been that of our complete dependence upon Central Europe for the glass apparatus needed in the laboratory. As soon as the situation was realised our manufacturers set to work, and with patriotic determination took great risks in laying down expensive plant, erecting machinery to meet the demand of the moment, and to make a serious endeavour to retain in our own country this exceedingly important Key Industry. One phase of the War has passed now, and the second—the conflict of industry—has begun, and it is becoming increasingly evident that it needs more than the money and enterprise of the manufacturers to win through. The glass industry called for chemists and obtained them, and in many glass-houses the old traditional mixtures and working methods have given place to standard formulæ and scientific treatment.

One very serious thing, however, is lacking, and that is skilled workmen. The old hands are insufficient to do the extra work, and unfortunately the trend of events during the last five-and-twenty years or so has been such that young labour has gone off into directions needing less application.

The new educational conditions call for a new method of training, and the fact that the boy of to-day is better educated both in mind and body than was the working boy of twenty years ago should make it possible, by a sound method of intensive teaching, to produce the necessary skilled labour in a very short time.

Much good work is being done for the glass industry by the Society of Glass Technology, the Glass Research Association, and other similar bodies, but we think that the first individual effort to gain skilled workmen is being made by one of the oldest of our London glassworks, of which we give an account below.

A NEW DEPARTURE IN THE GLASS INDUSTRY.

On Monday last, Mr. J. H. GARDINER, F.Inst.P., F.C.S., representing Messrs. James Powell & Sons (Whitefriars), Ltd., in company with Mr. P. Annett, Divisional Organising Officer for the Middlesex Educational Council, made a visit to Greenhill Drill Hall, and Harrow Weald Council Schools, and addressed the boys who, having reached the age of 14, were upon the point of leaving school. The object was to interest the boys in the glass industry, and to suggest to them the fine possibilities of good employment in the glass works that are now being erected at Wealdstone.

The Directors of the works, realising the serious lack of workmen to carry on the glass industry, have attacked the problem in a new and bold manner. The work carried on by the firm demands the highest possible skill, for they deal exclusively with high-class hand-made glassware. The present educational system keeps the boys at school until they are of such an age that it is hard to persuade them to go through the years of training that has hitherto been demanded to produce a skilled worker. The firm has, therefore, decided, with the assistance of the educational authorities, to attempt a system of intensive training. The scheme, which is due to Mr. J. H. Gardiner—who was for many years associated with the late Sir. W. Crookes—and whose skill in glass manufacture and manipulation is considerable, is in brief as follows.

The boys having been told the character of the work and the prospects that it holds out to them to learn one of the most important trades in the country, are invited to attend a series of evening continuation classes during the coming winter, a syllabus having been arranged to give a thorough grounding in English, arithmetic, the metric system, physical manipulation (woodwork, &c.), freehand drawing, and elementary chemistry and

physics. After attending the classes a selection will be made of the most promising boys, who will then pass through a special course of technical lectures in glass, its chemistry and properties. After this they will be drafted into the works, where a special laboratory is being fitted up in which they, for a certain number of hours a day, will learn the rudiments of the many branches of the industry. The remaining portion of the day they will be employed in making themselves useful in one or other of the many departments of the firm. During this time of probation and instruction they will receive a small nominal wage, and as soon as, by their skill and industry, they are able to do useful work they will be passed into the works proper, and be paid the union wages for the duties they are fitted for. The speed at which they will learn their business will depend upon their own efforts aided by all the assistance that can be given to them in the way of instruction.

THE FUNDAMENTAL CONSTANTS OF NATURE.

By HAWKSWORTH COLLINS.

If the atomic weights of two elements be divided by their respective specific gravities it is recognised that the quotients give the relative volumes occupied by single atoms of those elements.

If the molecular weight of a pure chemical compound be divided by its specific gravity, it is recognised that the quotient gives the sum of the relative volumes of the atoms which form that substance, i.e.,

$$\frac{\text{Molecular weight}}{\text{Density}} = \text{Molecular volume or } \frac{m}{d} = v.$$

The molecular refractivity of a pure compound is obtained from the formula :—

$$\frac{n^2-1}{n^2+2} \cdot \frac{m}{d} = \frac{n^2-1}{n^2+2} \cdot v$$

where n is the index of refraction.

The molecular magnetic rotation (M) of a pure compound is given by the formula :—

$$M = \frac{\alpha . m}{d} = \alpha v$$

where α is the magnetic rotation.

It is evident that the last two sets of constants are dependent upon the first set, viz., the molecular volumes.

It has been discovered that the relative volumes (when correctly found) of the elements reveal the constitution and structure of atoms in a definite manner. An example of this was given in the CHEMICAL NEWS, July 18, 1919.

It has also been discovered that the constants obtained from the heat of combustion are dependent in a particular manner upon the relative volumes of the elements.

Therefore, *the Relative Volumes of the Elements are the Fundamental Constants of Nature.*

These constants are invariable only at a constant temperature, so that it is necessary to choose a definite temperature. The ordinary one of 15° C. is most convenient as the great majority of experimental data are given at about that temperature and at ordinary atmospheric pressure. Since so much depends upon the relative volumes of atoms and molecules it is necessary to obtain these constants correctly.

No one can assert that both Perkin's and Bruhl's results with regard to Allyl bromide, *e.g.*, in Magnetic Rotation and Refractivity respectively are correct, for the former employed

Specific gravity 1·42532 at 15°
1·41057 at 25°
and the latter 1·3980 at 20°

There is a difference of about 1·5 per cent. in the two cases, and therefore the same percentage difference in the relative volumes. In other cases there is frequently a difference in their specific gravities of about 1 per cent.

Many scientists seem to think that Kopp solved the problem of relative volume, and that other people have slightly improved upon it; so it is necessary to go into the matter here, though as shortly as possible.

Kopp started by finding the relative volume of CH_2 at 0° C. to be 15·8. He then subtracted six times CH_2 from the total volume of hexane and found that the remaining two atoms of H together had a volume of about 30. He thought he had come to an absurdity, so he transferred his operations to the boiling points.

Dr. Cohen in his "Organic Chemistry,' published in 1913, says: "The value of CH_2 can be determined by a comparison of different homologous series. The following table gives the constants for different classes of compounds at the boiling point and also the maximum and minimum values observed :—

Series.	No. of Intervals.	Max & Min.	Mean
Alcohols	8	19·7—22·4	21·1
Fatty Acids	8	21·6—23·4	22·4
Aldehydes (aliph.)	4	19·0—22·0	20·7
Amines (aliph.) ...	5	20·4—20·6	20·5
Alkyl iodides ...	10	21·1—24·3	22·6
Paraffins	13	——	22·7
Esters	15	21·2—27·7	24·4
Ethers	13	21·6—28·5	24·3
Hydrocarbons (arom.)	5	21·0—22·9	22·1
Olefines	5	20·3—23·1	21·8

It will be seen that there is not only a considerable variation in the constants in the different series, but a wide divergence in the minima and maxima for the same series. It should, however, be pointed out that as a rule the value for CH_2 increases in ascending the series, and the longer the series and the wider the range of boiling points the larger the variation. There is clearly some missing factor which should be introduced to bring the various constants into uniformity."

These, then, are the data upon which Kopp founded his "discovery" that—the relative volume of CH_2 is *about* 22 at the boiling points of all substances containing it. And yet Dr. Cohen says: "With a delicate balance it is possible to estimate specific gravities with accuracy to one part in 100,000, and, as this is the principal factor involved in the determination of molecular volumes, the method experimentally leaves little to be desired." He then sums up all the attempts at the solution of this problem in the following words: "As no constant values can be attached to carbon, hydrogen and oxygen, it seems useless

to attempt to derive a molecular volume by the summation of atomic volumes."

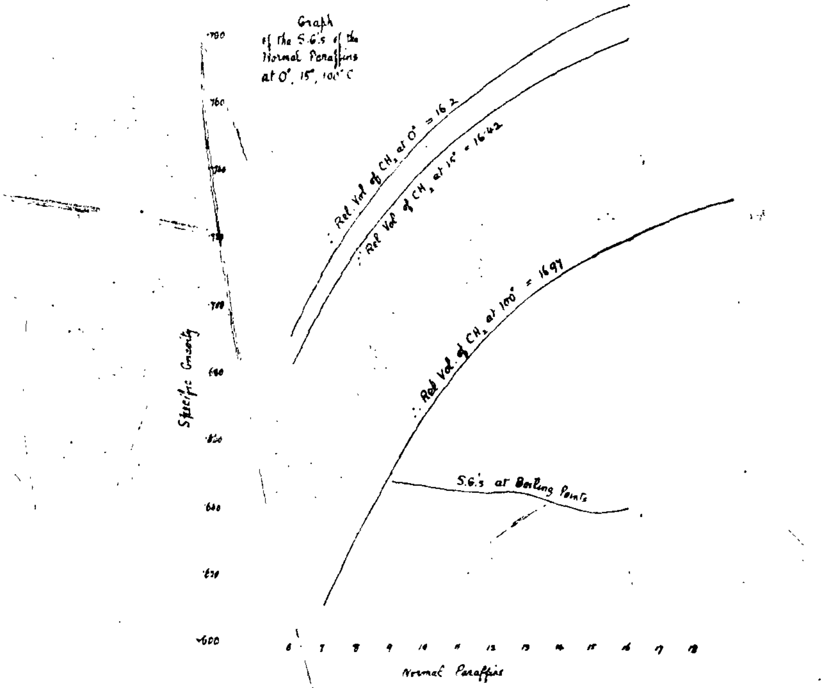
Dr. Cohen continues: "When Kopp's values for C, H, and O were calculated for compounds of the formula $C_aH_bO_c$ it was seen that the molecular volumes did not invariably conform to the calculated values and the property was therefore not strictly additive." Then he says: "Kopp showed subsequently that the calculated value would correspond with the observed result if account were taken of the oxygen atom . . . . The value for doubly linked oxygen was found a little higher that that for one atom of carbon . . . On this new basis the calculated values for forty-five different compounds did not vary by more than 4 per cent."

Now suppose there are two substances, A and B, which are similar in all respects, except that A has 5 methylene groups in its constitution and B 6; and suppose A boils at 120° C. and B at 150° C. At 120° the volume of CH_2 in each substance will be the same, and as B rises to its boiling point, the volume of each CH_2 is increasing. Therefore the volumes of CH_2 in the two substances are different at their boiling points.

Therefore it is impossible to compare the volumes of substances at their boiling points.

Explanation of the Graph.

The numbers 6-18 at the bottom of the graph represent the normal paraffins; *e.g.*, 9 stands for C_9H_{20}, 12 for $C_{12}H_{28}$ and so on. The numbers



Forty-five out of several hundred, and correct within four per cent! If chemists are satisfied with this, of course it is no use discussing the matter further.

Fortunately for Kopp, Maxwell and Clausius discovered that—at their respective boiling points and at atmospheric pressure the molecules of various liquids occupy a space very nearly 0·3 times the total apparent volume. So they decided that he was right in taking the various boiling points as the stepping-stones from which to make his discovery. So it is necessary here to produce a proof that it is impossible to compare the relative volumes of substances at their boiling points.

Kopp found that at 0° C. the volume of CH_2 in all substances is 15·8. The correct value is 16·2.

At 15° C. it will be shown later that the volume of CH_2 in hundreds of substances is always 16·42.

At 100° C. it is 16·97 (see graph).

And at any other arbitrary temperature the volume is constant, gradually increasing with the

0·600-0·790 written vertically represent specific gravities.

The three regular curves represent the graphs of the specific gravities of the paraffins at temperatures 0° C., 15° C., and 100° C.

If any point be chosen on the curve for 0°, say where the specific gravity of C_7H_{16} is 0·712, and if the molecular weight (100) be divided by 0·712, the result (140·45) is the relative volume of the molecule C_7H_{16} at 0° C.

If another point be taken on the same curve, say, where the specific gravity of $C_{14}H_{30}$ is 0·780, the relative volume is 253·85.

Subtract 140·45 from 253·85 and divide the result by 7 because there is a difference of 7 times CH_2 in the two molecules, the quotient is 16·2, which is the relative volume of the group CH_2 at 0°. Similar results will be obtained by taking any two points on the other two curves.

Now it is quite plain from these three curves that the graphs at any other arbitrary temperatures, say, 50°, 150°, and 200° would be similar

	0°	15°	100°
C_6H_{14}	0·691	0·6825	
	0·689 Warren	0·678 15°·5 Schorlr	
	0·695 Bartoli	0.6985 14° Lachowicz	
C_7H_{16}	0·712	0·7022	0·610
	0·7085 Warren	0·7023 14° Lachowicz	0·616 90° Thorpe
C_8H_{18}	0·727	0·7177	
	0·719 Thorpe	0·719 17°·5 Schorlr	
	0·728 Wurtz	0·7165 15°·6 Thorpe	
C_9H_{20}	0·740	0·7304	0·653
	0·733 Krafft	0·731 16° Lemoine	0·654 99° Krafft
	0·743 Lemoine	0·7330 0° Le Bas	
$C_{10}H_{22}$	0·751	0·7408	0·668
	0·7456 Krafft	0·7324 20° Lachowicz	0·669 99° Krafft
	0·764 Lachowicz	0·753 16° Lemoine	
$C_{11}H_{24}$	0·759	0·7497	0·682
	0·7560 Krafft	0·7448 15° Krafft	0·6816 99° Krafft
	0·7816 Bartoli	0·7581 20° V.N.	
$C_{12}H_{26}$	0·767	0·7572	0·693
	0·7655 Krafft	0·7548 15° Krafft	0·693 99° Krafft
		0·7684 20° V.N.	
$C_{13}H_{28}$	0·774	0·7637	0·702
	0·7716 Krafft	0·7608 15° Krafft	0·7008 99° Krafft
$C_{14}H_{30}$	0·780	0·7694	0·709
	0·775 5° Krafft	0·7681 15° Krafft	0·7087 99° Krafft
$C_{15}H_{32}$	0·784	0·7744	0·714
	0·776 10° Krafft	0·7724 15° Krafft	0·7136 99° Krafft
	0·7724 15° Krafft		
$C_{16}H_{34}$	0·788	0·7788	0·719
	0·7754 18° Krafft	0·7754 18° Krafft	0·7197 99° Krafft
	0·7707 25° Krafft	0·7707 25° Krafft	
$C_{17}H_{36}$		0·7828	0·724
		0·7764 22°·5 Krafft	0·7245 99° Krafft
		0·7714 30° Krafft	
$C_{18}H_{38}$		0·7863	0·728
		0·7768 28° Krafft	0·7288 99° Krafft
$C_{19}H_{40}$		0·7895	0·732
		0·7774 32° Krafft	0·7323 99° Krafft
		0·7720 40° Krafft	

curves of this nature are the only ones which would give constant volumes for CH_2.

But the graph of the specific gravities at the boiling points (as shown) does not lie anywhere near the general direction of these curves, and therefore it is quite evident that the relative volume of CH_2 at the boiling-points is not anything like constant.

The table contains the experimental data, which are required for the graph.

There being no regularity in the relative volumes of substances at their various boiling points, if absolute regularity can be demonstrated to exist at a fixed temperature, of course the question as to which method of procedure is correct will be settled. And if this regularity produces an independent proof of the Constitution and Structure of the Chemical Elements as given in previous papers, the matter will be doubly settled; for the relative volumes, as supposed to have been obtained from the various boiling points, lead to absolutely nothing.

Again, if this regularity leads up to the demonstration of the Correlation of Physical Constants, such as those mentioned at the commencement of this paper, of course the matter will be trebly settled.

A NEW INDICATOR.

By R. W. KINKEAD, B.Sc.

Moreau (*Compt. Rend.*, 1901, cxxxii., 838) studied the effect of methyl nitrate on methyl magnesium iodide, which resulted in dimethyl-hydroxylamine; and Sand and Singer (*Ann.*, 1903, cccxxix., 190) state that nitric oxide and alkyl-magnesium bromides result in nitroso alkyl-hydroxylamine, but no work appears to have been done on the effect of aromatic grignard reagents on the ONO_2 group.

By the action of ethyl nitrate on phenyl magnesium bromide a deep blue solution was obtained which has the properties of an indicator, turning pink with acids and blue with alkalies.

One equivalent of ethyl nitrate $C_2H_5ONO_2$ was added gradually to one equivalent of C_6H_5MgBr, cooled in ice. In a few minutes a vigorous reaction takes place, with the evolution of heat. After standing over night, pieces of ice were added and the mixture left for a few hours for the magnesium compounds to settle. The ethereal layer was then separated and the ether evaporated off. Solid Na_2CO_3 and water were then added,

when the mixture turned blue (later work shows that the colour is sometimes not developed till later). The mixture was then extracted with chloroform, when it was found that the blue colour remained in the aqueous layer.

This blue solution, which is obviously the sodium salt of the indicator, cannot be kept very long except as a very dilute solution. It was found that the best way to keep the substance was as an ethereal solution of the free indicator, so the blue solution was acidified, and the free red indicator extracted with ether.

The presence of chloroform seems necessary for the formation of the blue salt; all attempts to obtain the substance by extraction with ether resulting in compounds of the nitrolic acid type.

Like phenol phthalein, the substance cannot be used as an indicator in the presence of CO_2. In the absence of CO_2, very good results were obtained on testing the sensitiveness against phenol phthalein.

An N/10 solution of H_2SO_4 was titrated with an approximately N/10 solution of NaOH, using phenol phthalein and the new indicator.

Phenol phthalein :—

21·45 cc. NaOH solution neutralised 25 cc. N/10 H_2SO_4.

New indicator :—

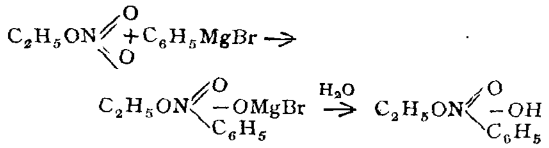
21·5 cc. NaOH solution neutralised 25 cc. N/10 H_2SO_4.

The end point with the new indicator is very sharp and easy to observe, the last drop of acid or alkali making a radical change in colour. Three titrations did not differ from each other by more than 0·05 cc.

The substance is, unfortunately, not very stable, losing its colour and indicating properties on keeping. On concentrating a water solution of either the free indicator or the sodium salt, the substance also loses its colour and properties. On allowing an ethereal solution of the free indicator to evaporate, a few drops of a dark red liquid were obtained, which soon decomposed.

Both the free indicator and the sodium salt are very easily reduced by SO_2, but H_2O_2 seems to have no effect.

The depth of the colour indicates that the substance is of high molecular weight. Evidently there is some fundamental change during the reaction, as the ordinary course of a Grignard reaction will not give a final substance which shows the necessary tautomerism to account for the indicating properties, *i.e.*, from theory we would expect :—



which will not give the quininoid-benzenoid change of indicators.

Further work will be carried out to find the constitution.

Sir Donald Currie Laboratories,
Queen's University, Belfast.

BRACKEN RHIZOMES AND THEIR FOOD VALUE.

By Prof. JAMES HENDRICK, B.Sc., F.I.C., University of Aberdeen.

(Concluded from vol. cxxi, p. 322.)

In certain respects bracken rhizomes resemble potatoes in composition. In Table I. some average figures for potatoes are quoted from the recently issued Report of the Food (War) Committee, Royal Society (Report on the Composition of Potatoes grown in the United Kingdom. Food (War) Committee, Royal Society, 1919). The figures for "Arran Chief" are given as those of a potato of good quality, above the average in dry matter and in nitrogen. As compared with the potato-tuber, the bracken rhizome contains more dry matter, but the dry matter is not quite so high in soluble carbohydrates, and is much more fibrous. In albuminoids it has already been seen that bracken rhizomes vary greatly. Potatoes are not so high in this valuable constituent as the B samples from Craibstone, but are higher than the A samples and than the samples in Table I.

In the case of the potato the main part of the solid matter consists of starch, which forms most of what is called "soluble carbohydrates." Bracken rhizomes also contain starch in considerable quantity, but, unlike the potato, the larger part of the soluble carbohydrates does not consist of starch, but of other substances of an undetermined nature.

In order to test whether animals would eat bracken rhizomes, and if so whether they would thrive upon them, a number of feeding trials were made with different classes of stock. It had already been reported from various sources that pigs will root up and eat bracken rhizomes, and it is recorded that these have been used in Europe as human food in times of scarcity. It is also on record that they formed a portion of the food of the natives of New Zealand at the time of the discovery of that country by Captain Cook. Attempts were made in our experiments to feed these rhizomes to pigs, to cattle, and to poultry.

On account of the many difficulties of the times it was almost impossible to arrange accurate feeding trials in 1918. Many people were suffering from lack of food stuffs, and were quite ready to give any promising new substance a trial, but very few had the necessary time and labour for weighing out foods and weighing stock, and otherwise giving the attention required for carrying out a reliable feeding experiment.

Some rough trials were first made, and these showed that at any rate bracken rhizomes were not very palatable to stock. Pigs would not eat them if they were already accustomed to a liberal diet, especially of concentrated foods. They took them only when they were in lean condition and, generally speaking, breeding stock consumed them more readily than feeding stock. It was also discovered that pigs ate them more readily if the rhizomes were given to them in the rough state, just as they were dug from the soil. It was at first assumed that if they were cleaned, chopped, mixed with other food, and cooked, the animals would consume them more readily. This proved to be quite wrong. Whether mixed with other

foods or not, pigs liked them better uncooked and unwashed.

The rhizomes were also tried in the form of meal. A few tons were dried in a malt kiln, after which it was found that they could be readily ground to meal. Indeed they could be ground too readily, for the workmen who carried out the milling raised serious objections to the work on account of its excessive dustiness. The meal so obtained was found to have the following composition :—

	Per cent
Moisture	9·81
Ether extract (oil, &c.)	2·54
*Albuminoids	9·56
Soluble carbohydrates	41·26
Fibre	20·49
†Ash	16·34
	100·00

* Containing total nitrogen	1·53
Containing protein nitrogen	1·49
† Containing siliceous matter (sand, &c).	11·26

The rhizomes which were dried were dug in May, when considerable growth of frond had already taken place, and they were not therefore of such good composition as if they had been dug a month earlier. It was found impossible, in view of the labour conditions then prevailing, to have them washed. This accounts for the high percentage of ash and sand which they contained.

Some feeding experiments with pigs and poultry were carried out with the help of members of the staff of the West of Scotland College of Agriculture, and the results are detailed in *Bulletin* No. 89 of the College, "Report on Experiments of the Feeding Value of Bracken Rhizomes for Pigs and Poultry." Preliminary trials were made at Holmes Farm, Kilmarnock, in which it was shown that breeding sows would eat considerable quantities of the rhizomes without any evil effect, but that well-fed feeding animals could not readily be induced to eat them. Then, through the kindness of the Directors of the Scottish Co-operative Wholesale Society, and of Mr. Geo.C.Young, their manager, a more accurate test was made on two pens of pigs at Calderwood Estate, East Kilbride, under the supervision of Mr. James Wyllie, B.Sc., of the West of Scotland College. These pigs had been somewhat short of food, and as their appetites were not pampered, they ate their allowance of bracken, whether in the form of untreated rhizomes or ground into meal, with apparent relish. But the results of the experiment were unsatisfactory, as the pen of pigs which got bracken in addition to the foods given to the other pen showed very little benefit from the extra food. The pigs which got bracken made a live-weight increase of 0·77lb. per head per day over a period of 140 days, while those without it made an increase of 0·71lb. per head per day. The small increases made all over were due to the poor diet on which the pigs were kept owing to the scarcity of feeding-stuffs, but the pen which had from 1lb. up to 2lb. of bracken meal per head per day as an addition to their ordinary diet did very little better than the others.

Mr. James Picken, Milton, Kircudbright, also tried both the untreated bracken and the meal with pigs, but was not in a position to do any weighing. He reported, however, that the pigs ate the bracken "with evident relish," and that it could "well replace other fresh vegetable food during the winter and spring months." Mr. Picken also noted that the bracken appeared to make the pigs lively, and that those which received it took more exercise than the others. He remarks : "This is a decided advantage to pigs 6 weeks to 4 months old, but over that age and during the fattening period it might be necessary to withold the roots, as these might unnecessarily excite the pigs and thus delay the fattening process."

The evidence, so far as it goes, indicates that bracken rhizomes in the fresh state or as meal might be of some use as a maintenance food for pigs, but are not of much use as a fattening food.

With poultry the results were still less favourable. The experiments were carried out with bracken meal at the Poultry Department, Holmes Farm, Kilmarnock, by Miss Agnes Kinross of the West of Scotland Agricultural College. The birds did not like the bracken meal even when it was mixed with a considerable amount of other food, and the pen which received a little bracken in their food during October and November did not lay so well as others which had received no bracken meal but an equivalent in other foods. The experiment indicates that bracken meal is not a suitable food for egg-production.

Bracken meal was tried with feeding cattle at Craibstone, the experimental farm of the North of Scotland Agricultural College of Agricutlure. The quantity available was not sufficient for an experiment on a scale large enough to be satisfactory, as for that purpose 8 or 10 bullocks would require to have been fed with the meal for a period of several weeks, and the quantity should gradually have been raised to several pounds per head per day. The quantity available was only sufficient to enable two bullocks to get 1lb. per head per day for two months. A comparison lot of two bullocks was similarly fed, but without bracken meal.

Lot 1 (bracken meal) received daily 95lb. turnips with oat straw *ad lib.*, and 2lb. bruised oats, 2lb. cereal offals, and 1lb. bracken meal.

Lot 2 received daily the same amount of turnips and straw and 2½lb. each of bruised oats and cereal offals.

Lot 2 therefore received ½lb. oats and ½lb. cereal offals instead of 1lb. bracken meal given to Lot 1.

Both animals in Lot 1 ate the bracken meal with evident relish, and they would have taken more had we been able to supply it. The increases made by the two lots were somewhat similar. In 56 days the cattle in Lot 1 made an average increase of 132lb., or 2·4lb. per head per day, while those in Lot 2 made an average increase of 113lb., or 2·0lb. per head per day. The lot which got the bracken meal therefore did slightly better than the other, but no weight can be attached to this result, as the number of animals under experiment was too small, and the amount of bracken meal fed was only a small proportion of the whole food. So far as it goes, however, the experiment shows

that feeding bullocks will readily eat a moderate amount of bracken meal, and that it appears to agree quite well with them.

It cannot be claimed that the feeding trials made with bracken rhizomes are anything more than preliminary. If the food value of this substance is to be tested thoroughly, much larger and more exhaustive trials will be necessary, and far larger quantities of the rhizomes would require to be obtained for the purpose. So far as they go, however, the trials indicate, as the analysis also does, that bracken rhizomes are not rich enough in the more valuable food constituents, such as albuminoids, to be of much use for anything but maintenance purposes, and that even for such purposes their usefulness is limited by the fact that they are not very palatable to certain classes of stock. Fortunately the circumstances which gave rise to these experiments have now passed away, and there is no longer the same danger of acute food scarcity in this country. In clearing from the bracken pest land which is good enough for cultivation, it may be possible to utilise the crop of rhizomes for feeding purposes, and these experiments indicate the value of this substance as a food and its limitations. They may also be of some interest in showing that the best time to cut bracken in order to weaken the rhizome is just when the frond is fully expanded.—*Transactions of the Highland and Agricultural Society of Scotland*, 1919.

CHEMICAL NOMENCLATURE AND PRONUNCIATION.

By J. NORMAN TAYLOR,
Washington Preparatory School, Y.M.C.A., Washington, D. C.

THE attention of educators is frequently called to the responsibility of secondary schools in the matter of preparing students for institutions of higher learning. Slow progress in college is attributed to lack of proper training in the student's preparatory life and not infrequently, failure in later life is ascribed to faults of secondary schools. A well-known research director, in writing of the lack of observation among chemists, states that "until a conscious effort is made in our primary education to meet this requirement, our advance in science will not be as speedy as it should" (Robert E. Rose, "The Education of the Research Chemist": *Jour. Ind. and Eng. Chem.*, 1920, xii., 948). A prominent educator implies this same lack of adequate preparation when he says, "And even if a freshman is somewhat dulled by his previous training, that seems scarcely a good reason for going on with the dulling process" (C. G. MacArthur: "The Scientific Teaching of Science": *Science*, new ser., 1920, lii., 350). Not only as regards preparation in science is deficiency laid at the door of the secondary school, but the poor English employed by so many college graduates is likewise charged to the same source. "A university graduate's inaptitude in the art of writing may be due, however, not to faults in his university course; more likely it is due in part to inefficient methods employed in the schools in which he obtained his earlier training in English" (George McLane Wood: "Suggestions to Authors": *U.S. Geological Survey*, 1916, p. 52).

Granting the fact that the lower schools are responsible for deficiencies which handicap the individual later on, it will be agreed that in secondary schools, method is of great importance. If we are to utilise the scientific method in teaching science, then it follows that in English-speaking countries good English, both with regard to spelling and pronunciation, should be used to convey our thoughts regarding science.

Although, perhaps, not a vital matter, it nevertheless appears to the writer that in teaching chemistry, the nomenclature used in secondary schools, so far as chemical words and terms are concerned, should agree with that employed in the higher institutions of learning. Dean Wilbur in speaking of good use in language, with particular reference to national use, says, "There is a law of national use that restricts us to those words that are in good use throughout the land . . . . A word that is not in good current use throughout the land is inefficient. Misunderstanding and perplexity and vagueness follow in the track of such a word" (William Allen Wilbur, "English Rhetoric": Judd and Detweiler, Inc., Washington, 1917, p. 260). In instances where chemical facts have been conveyed to the preparatory school student through the medium of corrupt English, confusion is bound to follow when his teacher in college uses pure English. And a change from pure English to corrupt forms is equally confusing. Certainly, there should not be any confusion in this regard and greater uniformity should obtain both as to terminology and pronunciation.

If it is correct to spell the word phosphorous with "ph," why should not the same principle in orthography be followed when writing the word sulphur? Good English would require that the names of the members of the halogen group be spelled with the final "e," as "fluorine," "chlorine," "bromine," and "iodine," and that they be pronounced as they are spelled and not as though the termination were "in." Likewise good English demands that the names of the chemical compounds known as the halides be spelled with the final "e" and that they be pronounced as they are spelled (consult "Inorganic Nomenclature" in the introduction to a "German-English Dictionary for Chemists," by Austin M. Patterson, published by John Wiley & Sons, Inc., New York, 1917). The names of analogous compounds should terminate in "ide," as for example: carbide, oxide, sulphide, phosphide, nitride, selenide. The names of these compounds should not be pronounced as though they terminated in "id." Acids, bases, and salts should be written and pronounced with a proper regard for good English (examples of good chemical nomenclature are to be found in "A Dictionary of Chemical Terms," by James F. Couch, published by D. VanNostrand Co., New York, 1920). In naming salts, the negative terminations should be "ate" and "ite" and the names should be pronounced as they are spelled and not as though they terminated in "at" and "it".

We must conclude with Dr. Crane that "good English in chemical literature, particularly in naming compounds, needs cultivation" (E. J. Crane, "Chemical Nomenclature": *Jour. Ind. and Eng. Chem.*, 1919, xi., 72). Its choice is based

on a proper regard for derivation and good usage, and this latter desideratum requires the use of pure Englsh by English-speaking people, both in writing and pronunciation. Elimination of un-English terminology in chemical literature may be brought about by following Dean Wilbur's injunction: "Cultivate your own heritage. Cast away your mannerisms and discard your provincialisms, but cherish as a trust your own style and express it in our common language for the common good." Let those who teach chemistry in our schools and colleges observe good usage and adhere strictly to real English rather than to individual preferences.—*School of Science and Mathematics*, U.S.A., December, 1920.

NEW METHOD FOR MANUFACTURE OF NITROGENOUS FERTILISERS.

An interesting paper on this subject was read by Mr. Thorsell, engineer, at a meeting of the Association of Engineers of Gothenburg, relating to a new method for preparation of nitrogenous compounds.

The method has many points of resemblance with the Haber process, but is more economic and more reliable in practice. It has also the advantage of giving useful by-products such as formiates oxalates, &c. Gaseous cyanogen is prepared by electrolysis of cyanides and the gas thus produced is run through concentrated hydrochloric acid, where it is transformed into oxamine, which represents a remarkable nitrogenous fertiliser containing 30 per cent nitrogen. Owing to the high cost of coal, heating is effected by electricity, and the expenditure of energy could thus be reduced to such an extent that only 12 kilowatts are needed to manufacture one kilogrm. of combined nitrogen.

Manufacture has already been commenced at the works of the Kvaeveindustrie Co., but as yet one cannot estimate the yield, for hitherto only a small portion of the plant is in work owing to the want of power. However, before long the fertiliser may be in the markets. The products comprise a series of by-products. To what extent will this new fertiliser compete with the hydro-electric nitrate of Norway? This, of course, will depend upon its value and price.—*L'Engrais*, November 19, 1920.

SIMULTANEOUS UTILISATION OF PYRITES CINDERS AND BISULPHATES FOR MANUFACTURE OF IMPURE FERRIC SULPHATE.

Coagulation of blood in abattoirs, deodorisation of putrid meat, waste fish, &c., require large quantities of ferric sulphate.

Consequently it is useful to manufacture this material cheaply by the action of residual pyrites on cinders (two substances of no appreciable value).

$$6SO_4NaH + Fe_2O_3 = \frac{(SO_4)_3F_2 + 3SO_4Na_2 + 3H_2O}{\text{Utilisable mixed salt}}$$

These experiments, made in the Iodet Angibaud Works of La Rochelle, might be continued for some time longer so as to be absolutely sure of the identity of this method with the old ones.

In any case, says M. Hutin (*Revue de Chemie Industrielle*, November, 1920), we have to thank Messrs. Jodet Angibaud for allowing us to make the following tests:—

Pure pyrites cinders 40 kilogrms. require 180 of SO_4NaH, supposed to be pure (40·8 per cent SO_4H_2 free) and give 100 of $(SO_4)_3H_2$ (mixed with variable quantities of SO_4Na).

This ferric sulphate can be manufactured at a cost of less than 5 francs per quintal (4s. per 220½lbs.). The exact quantity of pyrites and bisulphate to be added is calculated according to the cinders with an exact percentage of Fe_2O_3 and the real acidity of the bisulphate in SO_4H_2.

Modus Operandi.

The bisulphate is only slightly heated and then the dry cinders added in small quantities while stirring briskly. The reaction is very violent. The bisulphate pans are only filled 2/5. Heating is continued to remove water. The material run off should be very dry. To coagulate blood ¼-part of this magma ⅔ of blood. Coagulation is good cold, but the experimenter is of opinion that it would be better to heat. These experiments might be continued.

CORRESPONDENCE.

IS H COMPOSED OF A WHOLE-NUMBER PART (*A*) PLUS AN AUXILIARY PART (*B*) AND A ROTATING ELECTRON (*C*)?

To the Editor of the Chemical News.

Sir,—Referring to the above paper which appeared in your Journal of Dec. 31, 1920, through an oversight I omitted to mention that Langmuir gives helium the place shown in Table II. as well as the one over beryllium.

Referring to Table I., Co, Rh, and Ir should be deleted.

Referring to the descriptive matter under Table II., on p. 316, the letters "A" and "B" (in small caps.) should be in large caps. (A,B): the same as those following the words "Atomic Number."

There are two additional matters of interest I will note here.

If *a* is the fundamental material having the property of cohesion uniquely developed, it might condense round a nuclear part *b*, the latter possibly representing the *positive electron*, so that all atoms would contain at least one *b* nucleus, presumably situated at the centre of the atom. There are, however, apparently insuperable difficulties that stand in the way of such an idea. One of the difficulties would be the evaluation of the positive entity in different elements. Obviously, oxygen could not have more than one such entity if the *a*-value of unity is retained; and yet oxygen is supposed to have 8 negative electrons. There would thus be a very large excess of negative charge on (and in) the atom; equal to 7 negative electrons. Helium, for example, presents a similar difficulty.

The positions of *a* and *b* in the table shown might be reversed. Moreover, to make the table more complete, the negative electron should be placed therein; but it is obvious that it may be stretching matters too much to attempt to assign such an electrical entity to a place in the table.

It is of interest to note that A. G. Dempster reports in *Science* of December 10, 1920, that he has analysed magnesium by means of the positive-ray method, with the result that the atomic weights of the whole-number isotypes found are: 24, 25, and 26. Mg=24 is present in larger quantities than the others.—I am, &c.,

F. H. LORING.

COLOUR OF WATER.

To the Editor of the Chemical News.

SIR,—Sir W. D. Bancroft, in a recent paper (CHEMICAL NEWS, 1919, cxviii., pp. 197, 208, 222, 233, 248, 254) has discussed the question of the colour of water, with regard to the theories that its colour under various conditions is due to absorption of light, reflection by suspended particles, influence of dissolved matter, &c., but he has overlooked the aspect of the question raised by Ducleaux and (Mme.) E. W. Wollemann (*Journ. de Physique*, 1912, (v.), ii., 263). These investigators found that a long column of water appears blue by transmitted light at comparatively low temperatures, but it becomes green with rise of temperature, which they explain on the assumption that polymerised water molecules are blue, and the simple ones green, the former being broken up with increasing temperature. Confirmation is afforded to this explanation by the fact that solutions of colourless salts, which must contain less polymerised water molecules than pure water, are greener than pure water at the same temperature.

Of course, the vapour density of steam is much less than that required for the formula H_4O_2, and greater than for the formula H_2O, its density at about 100° C. corresponding with about 91 per cent of H_2O molecules, whilst more recent work has rendered it necessary to assume the existence of trihydrol (H_6O_3) in addition to dihydrol (H_4O_2) and hydrol (H_2O) in liquid water, in addition to which H. E. Armstrong assumed that two intramolecular forms of each "hydrol" also exist.

If these assumptions be true, then the six different forms of ice discovered by G. Tammann (*Zeit. physical Chem.*, 1910 and 1912) correspond to the six different molecules assumed to exist in liquid water.—I am, &c.,

E. TOMKINSON.

Barrow-in-Furness, December 24, 1920.

DIAMONDS.

To the Editor of the Chemical News.

SIR,—In the course of his paper on "Diamonds" (CHEMICAL NEWS, cxx., 303), Mr. J. R. Sutton mentions the breast-plate of the high priest at Jerusalem and raises the question as to whether one of the stones was a diamond, inclining to the belief that possibly it was. If, as Mr. Sutton suggests, the art of engraving on the diamond may have been known to the ancients, it is highly probable that some examples would have been preserved, but nothing of the kind has ever been found. While diamonds have occurred having natural markings simulating written characters, it is highly improbable that any of these would be sufficiently like the symbol of one of the tribes to pass muster, and in any case there is no evidence that the Jews had any knowledge of the diamond as a precious stone.

Moreover, not one breast-plate, but quite a number had to be constructed to replace those carried off by the Egyptian and Babylonian plunderers who devastated the Holy City at various dates from 971 B.C. The question was very fully discussed by Mr. L. Fletcher, Special Guide No. 5, British Museum (Nat. Hist.) 1911, who shows clearly that the name diamond given in the Bible is a mis-translation and that quite a different stone was involved.—I am, &c.,

THOMAS STEEL.

Sydney, N. S. Wales.

THE BRITISH COMMITTEE FOR AIDING MEN OF LETTERS AND SCIENCE IN RUSSIA.

To the Editor of the Chemical News.

SIR,—We have recently been able to get some direct communication from men of science and men of letters in North Russia. Their condition is one of great privation and limitation. They share in the consequences of the almost compelte economic exhaustion of Russia; like most people in that country they are ill-clad, underfed, and short of such physical necessities as make life tolerable.

Nevertheless, a certain amount of scientific research and some literary work still goes on. The Bolsheviks were at first regardless and even in some cases hostile to these intellectual workers, but the Bolshevik government has apparently come to realise something of the importance of scientific and literary work to the community, and the remnant—for deaths among them have been very numerous—the remnant of these people, the flower of the mental life of Russia, has now gathered together into two special rationing organisations which ensure at least the bare necessities of life for them.

These organisations have their headquarters in two buildings known as the House of Science and the House of Literature and Art. Under the former we note such great names as those of Pavlov the physiologist and Nobel Prizeman, Karpinsky the geologist, Borodin the botanist, Belopolsky the astronomer, Tagantzev the criminologist, Oldenburg the orientalist and permanent secretary of the Petrograd Academy of Science, Koni, Radlov, Bechterev, Latishev, Morozov, and many others familiar to the whole scientific world.

Several of these scientific men have been interviewed and affairs discussed with them, particularly as to whether anything could be done to help them. There were many matters in which it would be possible to assist them but upon one

in particular they laid stress. Their thought and work is greatly impeded by the fact that they have seen practically no European books or publications since the Revolution. This is an inconvenience amounting to real intellectual distress. In the hope that this condition may be relieved by an appeal to British scientific workers, Prof. Oldenburg formed a small committee and made a comprehensive list of books and publications needed by the intellectual community in Russia if it is to keep alive and abreast of the rest of the world.

It is, of course, necessary to be assured that any aid of this kind provided for literary and scientific men in Russia would reach its destination. The Bolshevik Government in Moscow, the Russian trade delegations in Reval and London, and our own authorities have therefore been consulted, and it would appear that there will be no obstacles to the transmission of this needed material to the House of Science and the House of Literature and Art. It can be got through by special facilities even under present conditions.

Many of the publications named in the Oldenburg list will have to be bought, the costs of transmission will be considerable, and accordingly the undersigned have formed themselves into a small committee for the collection and administration of a fund for the supply of scientific and literary publications, and possibly if the amount subscribed permits of it, of other necessities to these Russian savants and men of letters.

We hope to work in close association with the Royal Society and other leading learned societies in this matter. The British Science Guild has kindly granted the Committee permission to use its address.

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In the anatomy section are chapters on cell-structure, cell-division, and differentiation, with separate chapters on the non-living contents and by-products of cells. These are followed by sections devoted to the different tissues in turn, special emphasis being laid on the relations of structure to function in special tissues such as cork, secondary wood, and the like.

In the second section, dealing with life-histories and reproduction, a departure has been made from the usual system of "types." The common groups are all dealt with in turn, but as large a variety

of forms as possible is illustrated in each. In accordance with this principle, many interesting references of economic and commercial importance are introduced. The short concluding chapter deals simply with evolution and heredity; its interest is increased by clear diagrams of simple laws of variation and maps illustrating distribution.

Finally, there is a comprehensive appendix and an excellent index. The microscopic diagrams would be improved by statements of the exact magnifications.

NOTES.

CANDELILLA WAX IN MEXICO.—The candelilla is a plant about 25 inches high which grows extensively in Mexico, wild, especially in the locality of Monterey, where there are several works to extract the oil. At the end of August, 1919, only one of these works was running, owing to the poor prices of wax, the daily production being 662lb. The wax is extracted by putting the plants into water, which is then heated to boiling. Sulphuric acid is added, the separated wax being collected and poured into receptacles to solidify. It is then treated with steam in another vessel, and sulphuric acid. The refined wax is then run into moulds.—*Matières Grasses*, Nov. 15.

MR. JOHN AMES, General Secretary of the Industrial League and Council, has been appointed a member of the Commercial Panel of the Appointments Department of the Ministry of Labour. Mr. Ames' long and varied experience in connection with Labour matters renders him eminently suitable to assist in connection with the work which will devolve on this Panel. During the last two years, while officiating in the capacity of a Trustee and Member of the Executive Committee administering the King's Fund, of which Lord Parmoor was the Chairman, Mr. Ames found his experience very useful.

NEW COMMERCIAL MOTOR TAXATION.—The Solicitor to the Commercial Motor Users Association has compiled for the benefit of members a 24-page booklet, indicating the new rates of duty payable upon commercial motor vehicles as from January 1, together with a summary of the principal regulations governing the licensing and registration of such vehicles, which will also come into force on January 1. A limited number of copies of the booklet are available, and any user of commercial motor vehicles may receive a copy post free upon application to F. G. Bristow, F.C.I.S., F.S.S., A.M.Inst.T., General Secretary, Commercial Motor Users Association, 50, Pall Mall, London, S.W.1.

EXPORT OF SEED POTATOES.—The Board of Trade (Licensing Section) announces that as from the 16th instant seed potatoes may be exported to all destinations other than Soviet Russia without Privy Council Licence. Exporters are, however, warned that it will still be necessary to obtain certificates of freedom from disease from the respective Boards of Agriculture before export can take place to certain destinations.

CONTRACTS CLOSED.—The Turbine Furnace Co. Ltd., of 5, Budge Row, London, E.C.4 has received orders from (1) Messrs. A. Boakes Roberts & Co., Ltd., of Carpenters Road, Stratford, E. (chemical manufacturers) for one set of furnaces for a 30ft. by 8ft. Lancashire Boiler, with 3in. flues; (2) Messrs. The Gas Light & Coke Coke Co., Ltd., Westminster, have placed an order for one set of Turbine (Patent) Furnaces, for their tar and ammonia-producing works at Beckton. The furnaces are required to fit a Lancashire boiler of 8ft. 6in. diameter.

ESTIMATION OF PHOSPHATES AND ARSENIATES.—The sulphomolybdic solution hitherto employed to characterise, sometimes tin salts and sometimes hydrogen peroxide, gives an extremely sensitive reagent which M. Denigès employs in research of phosphates and arseniates. Its application will be particularly interesting in analysis of soils and identification of traces of Ph or As, both in biochemistry and legal chemistry.—*Comptes Rendus*, October 26th, 1920.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

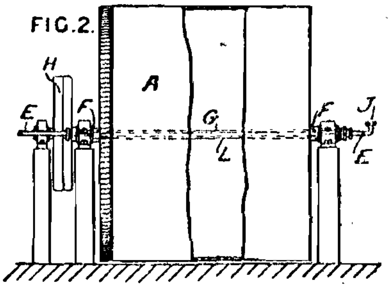
Mixing or comminuting and dissolving alkali silicates.—Mr J. F. Phillips, of Old Burlington Street, London, and another gentleman have obtained a Patent No. 151508, for an improved method of mixing or comminuting and dissolving alkali silicate in the presence of water under the action of steam or gas in a rotary mixer. The steam or gas is arranged to be directed in the form of jets throughout the whole internal space of the mixer and to impinge with force upon the particles of the material treated. Preferably, a pipe is arranged substantially along the axis of the barrel or cylinder and provided along its length with a number of orifices so as to cause radical jets of steam, etc., to play upon the material as it tumbles with the rotation of the barrel.

There may be a number of pipes substantially parallel to the axis or the steam may be admitted to a steam-chest at one end or both ends of the cylinder provided with a series of perforations which will cause a number of jets to be projected into the cylinder parallel to the axis. As shown on the accompanied drawing the cylinder A, is mounted on trunnions F and rotated by toothed gearing, and a steam-pipe E passing through the trunnions is fitted at the end with a safety valve J. The pipe E has radical orifices L and may be surrounded by a second or shutter pipe G having orifices normally registering with those in the pipe E.

By means of a handle H, the pipe G can be rotated to close the orifices L of the pipe E, or the pipe G may be arranged to be moved axially. The pressure of the steam or gas in the cylinder may be employed to discharge the finished material.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and forward on post free for the official price of 1/- each.

FIG.2.



Latest Patent Applications.

35629 & 35630—British Cellulose & Chemical Manufacturing Co.—Treatment of products made with cellulose derivatives. Dec. 18th.

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In the anatomy section are chapters on cell-structure, cell-division, and differentiation, with separate chapters on the non-living contents and by-products of cells. These are followed by sections devoted to the different tissues in turn, special emphasis being laid on the relations of structure to function in special tissues such as cork, secondary wood, and the like.

In the second section, dealing with life-histories and reproduction, a departure has been made from the usual system of "types." The common groups are all dealt with in turn, but as large a variety

of forms as possible is illustrated in each. In accordance with this principle, many interesting references of economic and commercial importance are introduced. The short concluding chapter deals simply with evolution and heredity; its interest is increased by clear diagrams of simple laws of variation and maps illustrating distribution.

Finally, there is a comprehensive appendix and an excellent index. The microscopic diagrams would be improved by statements of the exact magnifications.

NOTES.

CANDELILLA WAX IN MEXICO.—The candelilla is a plant about 25 inches high which grows extensively in Mexico, wild, especially in the locality of Monterey, where there are several works to extract the oil. At the end of August, 1919, only one of these works was running, owing to the poor prices of wax, the daily production being 662lb. The wax is extracted by putting the plants into water, which is then heated to boiling. Sulphuric acid is added, the separated wax being collected and poured into receptacles to solidify. It is then treated with steam in another vessel, and sulphuric acid. The refined wax is then run into moulds.—*Matières Grasses*, Nov. 15.

MR. JOHN AMES, General Secretary of the Industrial League and Council, has been appointed a member of the Commercial Panel of the Appointments Department of the Ministry of Labour. Mr. Ames' long and varied experience in connection with Labour matters renders him eminently suitable to assist in connection with the work which will devolve on this Panel. During the last two years, while officiating in the capacity of a Trustee and Member of the Executive Committee administering the King's Fund, of which Lord Parmoor was the Chairman, Mr. Ames found his experience very useful.

NEW COMMERCIAL MOTOR TAXATION.—The Solicitor to the Commercial Motor Users Association has compiled for the benefit of members a 24-page booklet, indicating the new rates of duty payable upon commercial motor vehicles as from January 1, together with a summary of the principal regulations governing the licensing and registration of such vehicles, which will also come into force on January 1. A limited number of copies of the booklet are available, and any user of commercial motor vehicles may receive a copy post free upon application to F. G. Bristow, F.C.I.S., F.S.S., A.M.Inst.T., General Secretary, Commercial Motor Users Association, 50, Pall Mall, London, S.W.1.

EXPORT OF SEED POTATOES.—The Board of Trade (Licensing Section) announces that as from the 16th instant seed potatoes may be exported to all destinations other than Soviet Russia without Privy Council Licence. Exporters are, however, warned that it will still be necessary to obtain certificates of freedom from disease from the respective Boards of Agriculture before export can take place to certain destinations.

CONTRACTS CLOSED.—The Turbine Furnace Co. Ltd., of 5, Budge Row, London, E.C.4 has received orders from (1) Messrs. A. Boakes Roberts & Co., Ltd., of Carpenters Road, Stratford, E. (chemical manufacturers) for one set of furnaces for a 30ft. by 8ft. Lancashire Boiler, with 3in. flues; (2) Messrs. The Gas Light & Coke Coke Co., Ltd., Westminster, have placed an order for one set of Turbine (Patent) Furnaces, for their tar and ammonia-producing works at Beckton. The furnaces are required to fit a Lancashire boiler of 8ft. 6in. diameter.

ESTIMATION OF PHOSPHATES AND ARSENIATES.—The sulphomolybdic solution hitherto employed to characterise, sometimes tin salts and sometimes hydrogen peroxide, gives an extremely sensitive reagent which M. Denigès employs in research of phosphates and arseniates. Its application will be particularly interesting in analysis of soils and identification of traces of Ph or As, both in biochemistry and legal chemistry.—*Comptes Rendus*, October 26th, 1920.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

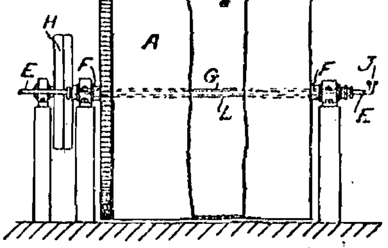
Mixing or comminuting and dissolving alkali silicates.—Mr. J. F. Phillips, of Old Burlington Street, London, and another gentleman have obtained a Patent No. 151508, for an improved method of mixing or comminuting and dissolving alkali silicate in the presence of water under the action of steam or gas in a rotary mixer. The steam or gas is arranged to be directed in the form of jets throughout the whole internal space of the mixer and to impinge with force upon the particles of the material treated. Preferably, a pipe is arranged substantially along the axis of the barrel or cylinder and provided along its length with a number of orifices so as to cause radical jets of steam, etc., to play upon the material as it tumbles with the rotation of the barrel.

There may be a number of pipes substantially parallel to the axis or the steam may be admitted to a steam-chest at one end or both ends of the cylinder provided with a series of perforations which will cause a number of jets to be projected into the cylinder parallel to the axis. As shown on the accompanied drawing the cylinder A, is mounted on trunnions F and rotated by toothed gearing, and a steam-pipe E passing through the trunnions is fitted at the end with a safety valve J. The pipe E has radical orifices L and may be surrounded by a second or shutter pipe G having orifices normally registering with those in the pipe E.

By means of a handle H, the pipe G can be rotated to close the orifices L of the pipe E, or the pipe G may be arranged to be moved axially. The pressure of the steam or gas in the cylinder may be employed to discharge the finished material.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and forward on post free for the official price of 1/- each.

FIG. 2.



Latest Patent Applications.

35629 & 35630—British Cellulose & Chemical Manufacturing Co.—Treatment of products made with cellulose derivatives. Dec. 18th.

35647—British Dyestuffs Corporation.—Manufacture of new series of soluble acid colouring-matters, and of new series of intermediate compounds for manufacture thereof. *Dec. 18th.*

35196—Clavel, R.—Process of dyeing cellulose acetate. Dec. 14th.

35523—Scheibler, H.—Manufacture of sulphur preparations of the thiophene series. Dec. 17th.

Specifications Published this Week.

132510—Gans, R.—Process for the production of iron-free ammonium alum from aluminium sulphate solutions containing ferric sulphate.

135187—Aktiebolaget Ferrolegeringar.—Production of chromium or alloys of chromium.

147543—Traube, W.—Process for the extraction of ethylene from gaseous mixtures containing it.

Abstract Published this Week.

Particulars are just to hand of a simplified method of obtaining alkali percarbonates which has been patented by M. H. Wade, of Hatton Garden, London, No. 152368.

Solid alkali percarbonates are obtained by treating sodium carbonate with hydrogen peroxide in presence of sufficiently limited quantities of water to produce the solid product directly, and of sodium chloride for salting out the product. A previous calcination of the sodium carbonate, and the addition of anti-catalysers such as sodium silicate, magnesium chloride and magnesium—sodium silicate are advantageous.

Messrs. Rayner & Co., will obtain printed copies of the published specification and will forward on post free for the sum of 1/- each.

MEETINGS FOR THE WEEK.

Saturday, January 8, 1921.

Royal Institution, 3. (Christmas Lectures). "The Haunts of Life—The Conquest of the Land," by Prof. J. Arthur Thompson.

Tuesday, January 11.

Royal Institution, 3. "The Mastery of the Air," by Prof. J. Arthur Thompson.
Institution of Electrical Engineers, 7. (At Edinburgh).
Institute of Metals, 7.30. (At Birmingham).
Institute of Metals, 6. (At Glasgow).

Wednesday, January 12.

Royal Society of Arts, 8. "Industrial Fatigue," by Charles S. Myers, M.D., Sc.D., F.R.S. W. L. Hichens (Chairman, Messrs. Cammell Laird & Co., Ltd.) will preside.
Institute of Electrical Engineers, 7. (At Birmingham).

Thursday, January 13.

Institute of Chemistry. (At Liverpool).
Institution of Electrical Engineers, 6. "Electrons," by Sir W. H. Bragg.
Optical Society, 7.30.

If in good condition, Sixpence per copy will be paid for any of the undermentioned numbers of the CHEMICAL NEWS which may be forwarded to this office:—

3048, May 24th, 1918.
3051, July 5th, 1918.
3053, August 2nd, 1918.
3054, August 16th, 1918.
3056, September 13th, 1918.
3059, October 25th, 1918
3062, December 6th, 1918.
3063, December 20th, 1918.
3064, January 3rd, 1919.
3066, January 17th, 1919.
3068, January 31st, 1919.
3069, February 7th, 1919.
3070, February 14th, 1919.
3075, March 21st, 1919.

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NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

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COUNTY BOROUGH OF BRIGHTON.

PUBLIC ANALYST.

APPLICATIONS are invited for the appointment of Public Analyst for the Borough from persons not engaged directly or indirectly in any trade or business connected with the sale of food or drugs in the Borough.

Forms of application with particulars of remuneration and conditions upon which the appointment will be made may be obtained on application to the undersigned.

Applications (with copies of two recent testimonials enclosed) and endorsed "Public Analyst" must be delivered at my office before 10 o'clock in the forenoon on the 31st day of January, 1921.

HUGO TALBOT,
Town Clerk.

Town Hall, Brighton,
December, 1920.

PATENTS, TRADE MARKS. Handbook and advice free—B. T. KING, British and U. S. Regd. Patent Attorney, 146a, Queen Victoria St., London. 35 years reference

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THE CHEMICAL NEWS.

VOL. CXXII., No. 3170.

EDITORIAL.

THE following papers have been received:—

"An Improvement in the Nomenclature of Organic Chemistry." By T. SHERLOCK WHEELER, A.R.C.Sc., A.I.C.

Some suggestions for a uniform system in which the names of compounds shall be connected with their formulæ, put forward in hope that the matter may claim the attention of those in the forefront of chemistry, and the possible formation of an International Congress to take up the subject upon lines similar to the Committee of Atomic Weights. Received January 6, 1921.

"The Storing of Light." By J. FREDERICK CORRIGAN.

The author's intention is to deal with the subject in two papers. The first gives an historical review of inorganic phosphorescence, from very early time to the dawn of modern science and the second will deal with the varied phenomena of phosphorescence and the modern theories which have been put forward to explain its cause. Received January 6, 1921.

POLYMERISATION IN THE SOLID STATE.

By WILLIAM R. FIELDING, M.A., M.Sc., Vict.
Senior Science Master at King Edward VII School, Lytham.

Introductory Note.

THIS paper is a continuation of "Aggregation at the Melting-Point" begun in CHEMICAL NEWS, vol. cxx., No. 3136. The formula I obtained

$$\frac{\text{M.P.} \times s}{\text{R}} = 4 \cdot 15$$

was based on the assumption that iodine and bromine were not associated at their melting-points and as a consequence I concluded that ice (at 0° C.) was $(H_2O)_2$. There is a consensus of opinion that ice is really $(H_2O)_3$ at its melting-point so that p for iodine and bromine will be 1·5 and not 1. All values of p (in the solid state) should, therefore, be calculated from

$$\frac{\text{M.P.} \times s}{\text{R}} = 6 \cdot 22$$

The results for ice (from 53°A to 273°A) are given in Table XXIV.

As the specific heats of most elements have not been determined at their melting-points, p has been calculated at the temperature of observation by substituting in

$$\frac{\text{T} \times \text{S}t}{\text{R}t} = 6 \cdot 22$$

where T is the temperature of observation on the absolute scale, and Rt is the rate of aggregation of a substance whose melting point is T. For since

$$\frac{\text{M.P.} \times s}{\text{R}} = 6 \cdot 22$$

then

$$\frac{\text{T} \times s}{\frac{\text{R} \times \text{T}}{\text{M.P.}}} = 6 \cdot 22$$

∴ R_T, corresponding to T, is approximately equal to $\frac{\text{R} \times \text{T}}{\text{M.P.}}$

The results for diamond and graphite are given in Tables I. and II. respectively.

TABLE I.

Absolute Temp.	R_T.	S_T.	Sols.	p.
222	27·5	0·7711	0·0635	12·1
262·4	33	0·7840	0·0955	8·20
283·7	36	0·789	0·1128	7·00
306·4	39·3	0·7983	0·1318	6·06
331	43·3	0·814	0·1532	5·3
358·5	48	0·8322	0·1765	4·71
413	55	0·829	0·2218	3·73
479	63·8	0·829	0·2733	3·03
520	69	0·8259	0·3026	2·73
880	122	0·8629	0·4408	1·95
1080	150	0·864	0·4489	1·92
1258	174	0·861	0·4589	1·88

TABLE II.

Absolute Temp.	R_T.	S_T.	Sols.	p.
223	27·7	0·7732	0·1138	6·80
262	33	0·7840	0·1437	5·45
284	36	0·789	0·1604	4·92
334	43·8	0·8163	0·1990	4·1
411·5	54·8	0·828	0·2542	3·25
475	63	0·8256	0·2966	2·77
522	69	0·8259	0·3250	2·55
915	128	0·8707	0·4454	1·95
1095	151	0·8583	0·4539	1·89
1250	172	0·856	0·4670	1·83

The results for boron, beryllium, and silicon are given without comment in Table III.

TABLE III.

Element	Absolute Temp.	S_T.	Sols.	p.
Boron (amorph.) ...	138	0·812	0·0707	11·5
Boron (amorph.) ...	235	0·825	0·1677	4·92
Boron (cryst.) ...	323	0·886	0·2518	3·51
Beryllium	296	1·057	0·397	2·66
Beryllium	323	1·08	0·4246	2·54
Beryllium	423	1·111	0·5060	2·19
Beryllium	530	1·095	0·582	1·88
Silicon (amorph.) ...	138	0·315	0·0913	3·45
Silicon (cryst.) ...	138	0·315	0·0861	3·66
Silicon (cryst.) ...	505	0·352	0·2029	1·72

In the following Tables (IV.—X.) the elements are treated from the point of view of the Periodic Classification.

TABLE IV.

Element.	Absolute Temp.	S_T.	Sols.	p.
Lithium	137	1·272	0·521	2·43
Lithium	336	1·41	0·941	1·5
Sodium	262	0·4056	0·2934	1·38
Potassium	234	0·2367	0·1666	1·42
Copper	330	0·1551	0·0933	1·67
Copper	405	0·1584	0·0968	1·64
Silver	100	0·0759	0·0467	1·62
Silver	400	0·093	0·0572	1·62
Silver	700	0·0921	0·059	1·56

The values for silver are very consistent.

TABLE V.

Element	Absolute Temp.	St.	Sols.	p.
Beryllium...	See Table III.			
Magnesium ...	308	0·405	0·245	1·65
Calcium	323	0·243	0·1804	1·35
Zinc	306	0·1476	0·0932	1·58
Cadmium	323	0·087	0·0548	1·59
Mercury	214	0·0465	0·0319	1·45

TABLE VI.

Element	Absolute Temp.	St.	Sols.	p.
Boron...	See Table III.			
Aluminium ...	100	0·305	0·1226	2·49
Aluminium ...	200	0·345	0·1731	2
Aluminium ...	300	0·3534	0·2053	1·72
Aluminium ...	700	0·369	0·2531	1·45
Gallium	291	0·135	0·079	1·71
Iridium	323	0·848	0·569	1·49

While p for silver only falls from 1·62 to 1·56 between 100°A and 700°A, p for aluminium falls from 2·49 to 1·45 for the same range of temperature. In the latter case the specific heat increases much more rapidly than in the former case.

TABLE VII.

Element	Absolute Temp.	St.	Sols.	p
Carbon	See Tables I. and II.			
Silicon	See Table III.			
Tin	323	0·0817	0·0545	1·5
Lead	240	0·0445	0·0306	1·45
Lead	307	0·463	0·0315	1·47

TABLE VIII.

Phosphorus (yellow)	189	0·286	0·169	1·70
Phosphorus (yellow)	266	0·3	0·1788	1·68
Phosphorus (yellow)	298	0·309	0·202	1·53
Phosphorus (red)	298	0·309	0·1829	1·67
Phosphorus (red)	340	0·3167	0·2121	1·49
Arsenic (cryst.) ...	318	0·13	0·0830	1·56
Arsenic (amorph.)	316	0·13	0·0758	1·71
Antimony	186	0·076	0·045	1·68
Antimony	383	0·0846	0·0503	1·68
Bismuth	307	0·462	0·0305	1·51

Generally, p for the amorphous element is higher than for the crystalline variety and where an element exists in two crystalline forms (cf. carbon) the values are by no means the same.

TABLE IX.

Element.	Absolute Temp.	St.	Sols.	p.
Sulphur (rhomb.)	83	0·248	0·0835	2·95
Sulphur (rhomb.)	304	0·299	0·163	1·83
Sulphur (monoclinic)	289	0·295	0·1774	1·66
Selenium (cryst.) ...	315	0·1221	0·084	1·45
Selenium (amorph.)	301	0·1204	0·0953	1·26
Selenium (amorph.)	312	0·1218	0·1125	1·08
Tellurium	100	0·0648	0·0462	1·39
Tellurium	200	0·0735	0·0471	1·56
Tellurium	300	0·075	0·0480	1·56
Tellurium	400	0·0781	0·0489	1·59
Tellurium	500	0·0774	0·0498	1·56
Tellurium	600	0·078	0·0507	1·54
Tellurium	700	0·078	0·0516	1·51
Chromium	309	0·1853	0·0997	1·86

p, for sulphur is only 1·83 even at 304°A, so that it consists mainly of S_2 molecules. Tellurium behaves rather erratically, p gradually increasing to 400°A, after which it gradually decreases to 700°A.

TABLE X.

Element	Absolute Temp.	St.	Sols.	p.
Iron	273	0·1688	0·1116	1·5
Iron	323	0·1734	0·1124	1·54
Iron	373	0·1803	0·1138	1·58
Iron	473	0·1789	0·1189	1·5
Iron	573	0·1759	0·1267	1·39
Iron	773	0·1818	0·1366	1·33
Iron (Temp. of Recalescence) ...	920+			
Iron	1123	0·1839	0·1699	1·08
Iron	1273	0·1808	0·1678	1·08
Cobalt	326	0·165	0·1067	1·54
Nickel	100	0·1401	0·0575	2·43
Nickel	200	0·159	0·0878	1·82
Nickel	300	0·1624	0·1054	1·54
Nickel	400	0·1696	0·1168	1·45
Nickel	500	0·168	0·1233	1·37
Nickel (critical Temp.)	623?			
Nickel	900	0·1773	0·1338	1·32
Nickel	1073	0·1768	0·1484	1·19
Nickel	1273	0·1749	0·1608	1·09
Ruthenium ...	323	0·0954	0·0611	1·56
Palladium ...	323	0·0912	0·0592	1·53
Palladium ...	905	0·0977	0·0714	1·37
Osmium	329	0·051	0·0311	1·63
Iridium	323	0·0505	0·0323	1·56
Iridium	973	0·054	0·0401	1·35
Platinum	323	0·0496	0·0323	1·53
Platinum	773	0·0523	0·0377	1·38
Platinum	1673	0·054	0·0390	1·38
Platinum	1873	0·056	0·0398	1·39

The most interesting element in this group. is iron. The value of p gradually increases to 373°A, after which it diminishes. During recalescence new groupings of the atoms evidently take place for at 1173°A p is only three-quarters of its former value; *i.e.*, there is a sudden change in the value of p from 1·33 to 1·08, when iron consists almost entirely of Fe_1 molecules. Now it is known that iron particles are more susceptible to new groupings than the molecules of any other element. An iron bar hammered in a magnetic field becomes magnetised through the arrangement of like poles in one direction; but heat or rough usage causes these temporary groupings to break up again and they disappear or become impossible above 983°A, at which temperature there is evidently no molecular complexity. It will be noticed that nickel does not behave in quite the same way unless its critical temperature is above 900°A (as in the case of iron).

To sum up: (1) Elements which have abnormal specific heats (elements of low atomic weights) are just those elements whose rate of change of p per degree is considerable.

(2) For most elements p diminishes as the temperature rises, and often, in the same group, as the atomic weight increases. An exception to the latter rule is exhibited by the triad iron, ruthenium, osmium, although this exception might disappear at the melting points (corresponding temperatures).

(3) Iron appears to behave normally until its critical temperature, when it suddenly changes from a mixture of Fe_2 and Fe_1 molecules to Fe_1 molecules.

(4) The values of R at the melting-points are relative to Br_5. The values of R_T quoted in this paper are equal to

$$\frac{R \times T}{M.P.}$$

The lower the temperature the smaller does R appear to be, and the greater is the value of p for any substance. At the absolute zero a substance will be incapable of aggregating but with increase of temperature the power to do so returns. On the other hand p will have its maximum value at the absolute zero. We might illustrate this phenomenon by the analogy of a siege. The people of the land represent an aggregation of units, more or less organised for defence. As the size of the aggregation (R_T) diminishes through casualties (starvation) the better organised (p) must the remnant become to resist the onslaughts of the enemy. Individual tastes and pursuits are sacrificed and even the individual identity is lost in the interests of the State. So, on approaching the absolute zero, when the power of aggregation has almost passed away, the atoms or molecules show their greatest degree of coalescence.

Polymerisation amongst Compounds.

Most, if not all, elements polymerise, but this property is shown more particularly by the elements in the first two rows, and they are able to exert their polymerising influence in their compounds. The results for the chlorides are given in Table XI.

TABLE XI.

Compound	Absolute Temp.	S_T.	Sols.	p.
LiCl	328	0·456	0·282	1·62
NaCl	330	0·333	0·214	1·56
KCl	330	0·264	0·173	1·53
RbCl	303	0·157	0·112	1·40
Cu_2Cl_2	331	0·199	0·138	1·44
AgCl	330	0·1354	0·0911	1·48
NH_4Cl	303	1·072	0·373	2·88
$MgCl_2$	304	0·303	0·191	1·59
$CaCl_2$	334	0·264	0·164	1·60
$CaCl_2.6H_2O$	264	0·927	0·345	2·68
$CaCl_2.6H_2O$	289	0·905	0·647	1·39
$SrCl_2$	329	0·184	0·120	1·53
$BaCl_2$	329	0·143	0·0896	1·59
$BaCl_2.2H_2O$	305	0·353	0·171	2·05
$ZnCl_2$	333	0·217	0·136	1·59
Hg_2Cl_2	326	0·082	0·052	1·58
$HgCl_2$	329	0·108	0·0689	1·56
$TiCl_4$	329	0·255	0·188	1·35
$SnCl_2$	333	0·155	0·1016	1·51
$SnCl_4$	329	0·190	0·1476	1·29
$PbCl_2$	333	0·106	0·0665	1·59
PCl_3	328	0·285	0·209	1·36
$AsCl_3$	329	0·216	0·176	1·23
$CuK_2Cl_42H_2O$	308	0·393	0·197	2·00
K_2PtCl_6	303	0·175	0·113	1·55
K_2ZnCl_4	305	0·234	0·152	1·55
K_2SnCl_6	308	0·21	0·133	1·58

The chlorides appear to polymerise to about the same extent as the elements composing them, but the presence of water leads to further polymerisation, the value of $CaCl_2.6H_2O$ being 2·68 at 264°A. This value drops to 1·39 at 289° A, due perhaps, to dissociating into anhydrous $CaCl_2$ and free (liquid) water whose p's are 1.60 and 1+ respectively. Three double chlorides have the p's of the separate chlorides. The most interesting compound in the list is ammonium chloride which appears to be $N_3H_{12}Cl_3$ or a mixture of $N_2H_8Cl_2$ and $N_4H_{16}Cl_4$.

The bromides and iodides give similar results but the fluorides are slightly more polymerised, for fluorine can claim to be a polymerising agent (compare H_nF_n where the complex molecules are probably due to both H and F). See Table XII.

TABLE XII.

Compound	Absolute Temp.	S_T.	Sols.	p.
$CaCl_2$	334			1·60
K_2ZnCl_4	305			1·55
CaF_2	309	0·370	0·209	1·77
$AlNa_3F_6$	309	0·459	0·238	1·92

It has previously been shown that sulphur does not polymerise to anything like the same extent as carbon, boron, &c. do (p=1·83 at 304°A) and this fact is comfirmed by determining p for the sulphides (Table XIII).

TABLE XIII.

Compound	Absolute Temp.	S_T.	Sols.	p.
Cu_2S	309	0·183	0·120	1·53
Ag_2S	326	0·1177	0·0746	1·57
ZnS	304	0·1975	0·120	1·63
HgS	309	0·0829	0·0517	1·59
SnS	329	0·1293	0·0836	1·55
SnS_2	327	0·159	0·1193	1·35
PbS	305	0·080	0·049	1·62
Sb_2S_3	334	0·145	0·084	1·72
Bi_2S_3	328	0·094	0·060	1·58
FeS	331	0·222	0·1357	1·62
FeS_2	305	0·24	0·1255	1·90
NiS	329	0·214	0·128	1·67
$CuFeS_2$	307	0·210	0·131	1·00

Whereas the raising of FeS to FeS_2 increases p from 1·62 to 1·90, increasing the valency has the opposite effect in the case of the sulphides of tin (cf. $SnCl_2$ and $SnCl_4$). This might point to the presence of SnS_2, SnS, and S even at ordinary temperatures, for when SnS_2 is heated, " a portion sublimes without decomposition but the greater part is resolved into sulphur and the monosulphide" (Roscoe and Schorlemmer, "Treatise on Chemistry," vol. ii., p. 846).

Table XIV. gives the results for the sulphates and it will be seen how the presence of oxygen and hydrogen (both polymerising agents) leads to greater polymerisation.

TABLE XIV.

Compound	Absolute Temp.	S_T.	Sols.	p.
$(NH_4)_2SO_4$	302	1·086	0·350	3·10
Na_2SO_4	315	0·477	0·229	2·09
K_2SO_4	329	0·393	0·190	2·07
$KHSO_4$	308	0·490	0·244	2·02
$CuSO_4$	335	0·369	0·184	2·00
$CuSo_4.5H_2O$	305	0·81	0·285	2·83
$CuSo_4.5H_2O$	335	0·826	0·316	2·61
$MgSO_4$	335	0·490	0·225	2·17
$MgSO_4.7H_2O$	304	1·051	0·362	2·91
$CaSO_4$	305	0·423	0·178	2·37
$CaSO_42H_2O$	304	0·667	0·259	2·58
$BaSO_4$	306	0·247	0·108	2·28
$BaSO_4$	327	0·251	0·1128	2·22
$PbSO_4$	308	0·190	0·0827	2·29
$FeSO_4.7H_2O$	305	0·931	0·346	2·70
$CoSO_4.7H_2O$	295	0·914	0·343	2·67

The conversion of a sulphide into a sulphate raises p from about 1·65 to 2+ (for anhydrous salts), a tribute to the polymerising properties of oxygen. The presence of water of crystallisation still further increases p. Ammonium sulphate is

$$\{(NH_4)_2SO_4\}_3$$

or a mixture of $(NH_4)_4S_2O_8$ and $(NH_4)_8S_4O_{16}$.

The results for a few hyposulphites are given in Table XV.

TABLE XV.

Compound	Absolute Temp.	St.	Sols.	p.
$Na_2S_2O_3$	335	0·435	0·221	1·96
$Na_2S_2O_3.5H_2O$ ...	301	0·847	0·445	1·90
$K_2S_2O_3$	333	0·360	0·197	1·83
BaS_2O_3	331	0·235	0·163	1·44
PbS_2O_3	331	0·185	0·092	2·00

The hydrated sodium salt is less polymerised than the anhydrous salt, surely a rare occurrence, although it should be pointed out that the specific heats have been supplied by different observers. The low value for the hydrated salt may be due to partial decomposition, decomposition into $Na_2S_2O_3$ and H_2O (whose p's are 1·96 and 1+ respectively).

The hyposulphates are less polymerised than the corresponding sulphates owing to the substitution of a sulphur atom for a more highly polymerising oxygen atom.

We should expect the borates, which contain two highly polymerising elements, boron and oxygen, to be more highly polymerised than the sulphates, and this surmise is confirmed by the results quoted in Table XVI.

TABLE XVI.

Compound	Absolute Temp.	St.	Sols.	p.
KBO_2	329	0·477	0·2048	2·32
$NaBO_2$	330	0·592	0·2571	2·31
$Pb(BO_2)_2$	329	0·232	0·090	2·58
$Na_2B_4O_7$	305	0·616	0·229	2·70
$Na_2B_4O_7$	329	0·627	0·238	2·62
$Na_2B_4O_7.10H_2O$	308	1·083	0·385	2·82
$K_2B_4O_7$	331	0·543	0·2198	2·48
PbB_4O_7	329	0·322	0·114	2·82

The bigger the percentage of polymerising atoms present, the more polymerised is the salt. This fact is very obvious from the lead salts (sulphur is not included as a polymerising agent as its p is only a little more than that of lead).

Compound	Percentage of Polymerising Atoms (Boron and Oxygen)	p.
$PbCl_2$	0	1·59
PbS	0	1·62
PbS_2O_3	50	2·00
$PbSO_4$	67	2·25
PbB_2O_4 ...	86	2·58
PbB_4O_7 ...	92	2·82

We have seen the effect of a basic polymerising radicle (NH_4) in ammonium chloride (where $p=2·88$) and ammonium sulphate, which contains both a basic and an acidic (SO_4) polymerising radicle ($p=3·10$). What will be the effect of the juxtaposition of the ammonium and the nitric acid radicles? See Table XVII.

TABLE XVII.

Compound	Absolute Temp.	St.	Sols.	p.
NH_4NO_3	295	1·071	0·455	2·35
$NaNO_3$	316	0·57	0·265	2·15
$NaNO_3$	329	0·575	0·278	2·07
KNO_3	303	0·474	0·232	2·04
KNO_3	329	0·483	0·239	2·03
$AgNO_3$	330	0·286	0·1435	2·00
$Sr(NO_3)_2$	305	0·408	0·181	2·25
$Ba(NO_3)_2$	305	0·330	0·145	2·28
$Ba(NO_3)_2$	329	0·336	0·1523	2·19
$Pb(NO_3)_2$	305	0·259	0·110	2·35
$Pb(NO_3)_2$	331	0·266	0·1173	2·26

p for nitrates lies between the values for the chlorides and the sulphates, except in the case of ammonium nitrate.

Results for a few phosphates, chromates, chlorates, and arsenates are given in Tables XVIII., XIX., XX., XXI. respectively.

TABLE XVIII.

Compound	Absolute Temp.	St.	Sols.	p.
KH_2PO_4	305	0·564	0·208	2·71
$Na_2HPO_3.12H_2O$	264	1·145	0·454	2·52
$NaPO_3$	303	0·469	0·217	2·16
$Ca(PO_3)_2$	329	0·444	0·199	2·24
$Na_4P_2O_7$	330	0·479	0·228	2·09
$K_4P_2O_7$	330	0·385	0·191	2·01
$Pb_2P_2O_7$	327	1·822	0·821	2·22

TABLE XIX.

K_2CrO_4	306	0·345	0·189	1·83
$K_2Cr_2O_7$	309	0·359	0·186	1·92
$PbCrO_4$	308	0·179	0·090	1·98

TABLE XX.

KCl	—	—	—	1·53
$KClO_3$	307	0·391	0·194	2·01
$KClO_4$	303	0·415	0·190	2·19
$Ba(ClO_3)_2.H_2O$	305	0·357	0·157	2·26

TABLE XXI.

$KAsO_3$	331	0·301	0·156	1·92
KH_2AsO_4	304	0·426	0·175	2·43
$Pb_3(AsO_4)_2$ ...	328	0·141	0·0728	1·94

Table XXII., which concerns the carbonates, is interesting as it shows the various forms of calcium carbonate to be almost equally polymerised.

TABLE XXII.

Compound	Absolute Temp.	St.	Sols.	p.
Na_2CO_3	306	0·543	0·246	2·20
Na_2CO_3	330	0·552	0·2727	2·02
K_2CO_3	305	0·417	0·206	2·02
K_2CO_3	334	0·426	0·216	1·97
Rb_2CO_3	305	0·249	0·123	2·02
$CaCO_3$:				
Calcspar ...	305	0·479	0·206	2·33
Arragonite ...	303	0·479	0·203	2·35
Marble (white	330	0·489	0·216	2·26
Marble (grey) ...	333	0·489	0·210	2·33
$SrCO_3$	326	0·33	0·1475	2·24
$BaCO_3$	328	0·248	0·1104	2·24
$PbCO_3$	305	0·179	0·0791	2·25
$FeCO_3$	326	0·42	0·1934	2·16

Table XXIII. is an attempt to arrange the salts of potassium and lead in the order of p. Perhaps, this order will not hold good for the acids themselves, which will have still higher values. *E.g.*,

from the specific heats of sulphuric acid at 243° A and 273°A, p is 2·80 and 2·48 respectively.

TABLE XXIII.

Acid		p. Pb.	k
$H_2B_4O_7$	...	2·82	2·48
HBO_2	..	2·58	2·32
$HClO_4$	..	—	2·19
$HgSO_4$	..	2·29	2·07
HNO_3	...	2·35	2·04
H_2CO_3	...	2·25	2·02
$HClO_3$	...	—	2·01
$H_4P_2O_7$	...	2·22	2·01
H_2CrO_4	...	1·98	1·83
$H_2S_2O_3$	...	2·00	1·83
H_2S	... ...	1·62	—
HCl	... ..	1·59	1·53

The values of p for a number of oxides are given in Table XXIV. p is highest for B_2O_3, Co_2, and H_2O which are composed of highly polymerising elements. The addition of an atom of oxygen (MnO to MnO_2) has the effect of raising p from 1·74 to 2·07.

TABLE XXIV.

Compound	Absolute Temp.	ST.	Sols.	p.
Cu_2O	308	0·201	0·111	1·81
CuO	308	0·243	0·128	1·89
MgO	335	0·490	0·2439	2·01
$Mg(OH)_2$	308	0·828	0·312	2·65
ZnO	330	0·241	0·1248	1·94
HgO	308	0·0888	0·053	1·68
B_2O_3	330	0·698	0·2374	2·94
Al_2O_3 (corundum)	327	0·475	0·1976	2·40
Al_2O_3 (sapphire)	326	0·475	0·2173	2·18
SiO_2 (quartz) ...	308	0·481	0·186	2·59
SiO_2 (opal)	309	0·481	0·185	2·59
SiO_2 (Hyalith) ...	306	0·48	0·1755	2·73
TiO_2	330	0·366	0·1716	2·13
SnO_2	305	0·190	0·0894	2·13
SnO_2 (tinstone) ..	330	0·194	0·0936	2·07
PbO	307	0·086	0·0553	1·56
As_2O_3	328	0·2468	0·1276	1·94
Sb_2O_3	332	0·1698	0·0927	1·83
Bi_2O_3	328	0·105	0·0609	1·72
Cr_2O_3	309	0·31	0·177	1·79
MoO_3	305	0·2662	0·154	1·72
WO_3	310	0·166	0·0894	1·85
MnO	329	0·275	0·157	1·74
MnO_2	305	0·330	0·159	2·07
Fe_3O_4	305	0·289	0·156	1·85
Fe_2O_3	305	0·3	0·1565	1·90
$MgAl_2O_4$ (spinelle)	304	0·472	0·194	2·43
$CaSiO_3$ (wollastonite)	308	0·414	0·178	2·32
$ZrSiO_4$ (zircon) ...	309	0·315	0·132	2·39
CO_2	140	0·606	0·215	2·82
SO_2	127	0·413	0·228	1·81
H_2O	53	1·232	0·146	8·44
H_2O	140	1·510	0·285	5·30
H_2O	225	1·529	0·463	3·30
H_2O	273	1·556	0·504	3·08

Ice will be about $(H_2O)_{12}$ at the absolute zero.

I intended in this article to make some reference to the main group of organic compounds, but the subject, though of great interest, must be reserved for some future occasion. A few results are given in Table XXV.

TABLE XXV.

Compound	Absolute Temp.	ST.	Sols.	p
C_2Cl_6	300	0·322	0·178	1·81
C_2Cl_6	303	0·322	0·194	1·67
C_2Cl_6	307	0·324	0·277	1·17
$C_{12}H_{22}O_{11}$:				
(Crystalline) ...	309	1·2775	0·3005	4·25
(Amorphous) ...	309	1·2775	0·342	3·74
C_6H_6	223	1·416	0·262	5·40
	243	1·425	0·292	4·88
	263	1·437	0·376	3·82
	273	1·444	0·460	3·14
	273	1·444	0·397	3·64
$C_{10}H_8$	223	1·294	0·240	5·39
	288	1·336	0·314	4·25
	318	1·369	0·326	4·20
	338	1·382	0·334	4·13

To Calculate the Molecular Weight of a Solid Substance from its Specific Heat.

By means of the specific heat the molecular weight of any solid substance (element or compound) can be determined with ease at any temperature without vapourising it. All that is necessary is a reliable knowledge of the behaviour of some pure solid which can serve as a standard. E.g., ice at 273°A. Now,

$$\frac{T \times s \text{ (calc.)}}{R} = 6{\cdot}22$$

$$\therefore\ T \times p \times s \text{ (ols.)} = 6{\cdot}22\ R$$

$$= 6{\cdot}22 \left\{ \frac{\text{Melticular Weight}}{\text{Formula Wt. of } H_2O} \times 3 \right\}$$

$$= 6{\cdot}22 \times \frac{\text{Melticular Weight}}{\text{Average atomic weight of atoms present } (=6)}$$

$$\therefore\ 6T \times 3 \times {\cdot}5 = 6{\cdot}22 \times \text{Melticular Weight.}$$

$$\therefore\ 9T \quad = 6{\cdot}22 \times \text{Melticular Weight (1)}$$

For any other substance (x) whose specific heat (s_x) is known at T the formula becomes

$$W_x \times T \times p_x \times S_x = 6{\cdot}22 \times \text{Melticular Weight,}$$

(2) where W_x is the average atomic weight of atoms composing x.

Dividing (2) by (1)

$$p_x = \frac{9}{W_x \times S_x}$$

Thus, for any temperature,

$p\ w\ s$ = a constant,

or, the "molecular" heat (*i.e.*, the polmericular heat) of any element or compound at any temperature is directly proportional to the number of atoms present and is independent of their nature.

Example.

What is the molecular weight of solid formic acid whose specific heat at 273°A is 0·430?

$$\text{Here, } W_x = \frac{46}{5}$$

$$S_x = 0{\cdot}430$$

$$\therefore\ p_x = \frac{9}{\frac{46}{5} \times 0{\cdot}430}$$

$$= 2{\cdot}27$$

$\therefore$ Formic acid at 273°A is $(H.COOH)_{2{\cdot}27}$

This method of finding molecular weights can be applied to the liquid and gaseous states.

(To be continued.)

HOW COAL WASTAGE INCREASES TUBERCULOSIS.*

By W. H. CASMEY.

We are using nearly 200 million tons of coal per year, 25 per cent of which is wasted by stoking at the wrong time and giving approximately 80 per cent more air than is required for economically burning the coal, and it is the effect of this excess air used which has such a disastrous effect both on human life and vegetation.

Consider the earth as forming the base of a sea of air, the composition of which as before stated is 78 per cent nitrogen and 21 per cent oxygen and 1 per cent of other gases including 1 part of carbon dioxide in 2500 of air, and that to maintain health this proportion must be maintained within a margin of 3 parts CO_2 to 10,000 or air, in excess of normal conditions, say the maximum CO_2 in 10,000 must not exceed 7 parts.

The area of the British Isles is 121,000 square miles, and to keep our figures small it is proposed to take one square mile as a unit and we find we consume 1612 tons of coal per year for each square mile and when using coal on scientific lines 29,000 tons of air is required per square mile, say 845 million cubic feet. The coal consumption in Wakefield is 22,000 tons per square mile, and in Bradford 37,000 tons.

The atmosphere will absorb the carbon dioxide (CO_2) in the gases and gradually diffuse it and so maintain the standard 4 parts in 10,000 from which, as already inferred, vegetation is fed, but under general working conditions of 30 pounds of air per pound of coal the gases discharged into the atmosphere is 48,000 tons per square mile as against 29,000 tons, the result being that this overcharge which is accompanied by a large quantity of dust and products of imperfect combustion which fouls the atmosphere and does more in destroying both life and vegetation than any other cause, and in our industrial centres the dust fall during the year ranges from 400 to 600 tons per square mile, whereas in the suburbs the deposit is less than 30 tons.

Is there any wonder that under such conditions it is next to impossible to grow either flowers or fruit in such areas. Two hours' sunshine is taken from us per day with such a mass of floating dust and the lungs of plant life are choked. Why? Because we have not followed the Designer's law already given, and for these losses and annoyances we have only our stupid selves to blame.

If we could follow in burning coal the same laws of proportion as used in all our works and factories we could make no mistake, but the boiler house, the greenhouse and the house fires seldom receive any sensible consideration.

Under normal conditions the whole of the blood in the human body is brought into contact with the air once per minute, and the air we expire may very well be considered as the smoke from the boiler furnace, as the law of combustion as already stated, applies to both.

The parallel goes still further, the safety valve of the body is set at 98°, and no matter when in health if surrounded by air at 20° or 200°, the temperature of the blood never varies, in one case deeper breathing is carried on, which supplies more air to the body and therefore more heat is generated, and in the other case the heat escapes through the sweat glands in the form of moisture.

We take in when we breathe oxygen and expire CO_2, but if the outside air already holds more CO_2 than the standard 1 part in 2500, we are not maintaining the health of the body, as no matter how foul the air may be by which we are surrounded, we are compelled to breathe it. Here the senses of smell and taste cannot help us, whereas they enable us to reject impure food and drink.

By great care in our drainage schemes and water supplies, typhoid and typhus fevers are now practically unknown, and as the greater number of diseases are air-borne, every care should be taken to maintain a pure atmosphere, but what are we doing in this direction. The appointment of a smoke inspector appears to the authorities as the only thing necessary, but food and water inspection are considered of vital importance, and so they are, but not more so than the air we are compelled to breathe.

Let us now consider how an impure atmosphere affects us; take as an example one of our large schools accommodating say 1000 scholars.

In the act of breathing, CO_2 is expelled from the lungs and to dilute the expired air so that it contains not more than 7 parts of CO_2 in 10,000 of air, it is necessary to supply 3300 cubic feet of air per child per hour, or a total for the school of 3,300,000 cubic feet, so that impurities in the outside air are very much in evidence inside the school.

The air supply to this school equals 100 tons of air per hour, and without mechanical means it is not possible to secure it, and the result is, that as a rule, windows are opened and the outer air obeying the laws of gravitation merely falls through the windows, causing what we call draughts, resulting in colds to the youngsters near the windows, and even when the windows are closed, the so-called draughts continue, caused by the quick transmission of heat through the glass which is six times as rapid as through the walls, and every 10° fall in temperature increases the weight of a cubic foot of air 1 grain, the draught therefore is again a case of gravitation due to heat transmission.

We cannot burn coal to the best advantage without a proper air supply, nor maintain health either, and we have but few schools or public buildings in Yorkshire where anything like scientific ventilation is in use, coal is wasted due to havng too great a supply of air, life is wasted by not having a sufficient supply. There is no wonder that schools are often closed for weeks together due to the outbreak of infectious diseases directly caused through lack of fresh air. There, no doubt, tuberculosis often originates.

Every buildng should be so fitted up with heating and ventilating plant that the correct temperature and purity of air is maintained under all conditions and the ventilation such that the building breathes in unison with the number of people occupying it, and it is only by adopting the lines thus indicated that tuberculosis can be stamped out.

The late King Eward the VII., when addressing a conference on the subject of the fresh air cure for tuberculosis asked the pregnant question: "If preventable, why not prevented?" And we still await the answer.

*Extract from a Lecture given before the Wakefield Paxton Society, January 1st, 1921.

To save coal we must burn it, the outside air will then be kept pure; to prevent consumption every building where people are gathered together must be made equal to a fresh air hospital by heating and ventilation. Our trams and railway carriages must carry the number of people they are constructed to carry, and no more, and when we give the same attention to the air we are compelled to breathe as to our water and food supplies we shall have attained what has been attempted in a half-hearted way for many years; a kingdom free from coal wastage and tuberculosis.

In conclusion, let us draw the tangled cords together and we find a very simple problem. The law of combustion applies both to the human frame and the boiler furnace in one, oxygen is breathed in and CO_2 breathed out. Plant life takes in CO_2, but breathes out oxygen; CO_2 may therefore be considered as the link between the animate and inanimate kingdoms.

By careless burning of our coal we discharge other gases than CO_2 into the atmosphere and practically suffocate the weaker members of plant life, thus interfering both directly and indirectly with the Creator's design.

For months every newspaper has been giving columns on national economy, whatever that means, but little has been said on the foundation on which true economy is built.

Dear coal means dear metal, the machines made from these are proportionately dear, and so is the products they assist in producing. The reason is, because the demand for coal has exceeded the supplies, and our coal exports have fallen. If we all unite in using coal as it should be used, we should save 50 million tons per year; this would bring the supplies in excess of demands, with the natural results, easier prices; this would also enable us to again export more coals, thus bringing into our country cheaper produce, therefore, cheaper living, and the stability of the country would be in the direction of pre-war conditions.

The economy we require is not one made and practised in the House of Commons only, but made and practised daily in each one of our 5,000,000 houses and 40,000 works, and the result of such economy would be "reduction in coal consumption," "reduction of our death rate," and further, a big reduction in the cost of living. Remeber the three "R's" during 1921.

PRESENT POSITION OF THE FINE CHEMICAL INDUSTRY.

By C. A. HILL.

THE British fine chemical industry is to-day in a critical position—a conditon resulting from a combination of circumstances. According as the Government redeems its pledge or not, the industry can either stabilise itself and become second to no other fine chemical industry in the world, or, alternatively, will sink back into its pre-war condition, or something very nearly like it.

The chemical industry consists of two parts:—(1) heavy chemicals; (2) fine chemicals. The former has several main branches, such as the acid, the alkali, and the soap industries; all of these were well-developed and well-organised British industries before the war. The latter has very many branches, but none was well-developed before the war, nor was the industry organised. Dyes constitute a group of fine chemicals, so large and important that they are generally considered as a separate branch of chemical industry; actually, however, they cannot be thus divorced from the rest of the fine chemical industry. Parliament is legislating for the dye industry; it must also legislate for the remainder, and no short-sighted policy should be allowed to interfere in this important national question.

Comparatively few people outside the profession of chemistry know what the fine chemical industry is; still less do they know of its many and far reaching ramifications, by reason of which it is essentially and truly a "key" industry, and therefore of vital importance to the national welfare. Before the war even chemists, generally, had rather vague notions as to what precisely fine chemicals are. How often has one heard such loose expressions as "medicinal and fine chemicals' or "fine chemicals and analytical reagents," and the like Indeed, a notorious Board of Trade memorandum, born a little more than a year ago and now decently interred, made use of the expression analytical reagents and the following fine chemicals." "Fine chemicals" is the term comprehensive of *all* fine chemicals, and includes the various groups:—(1) laboratory chemicals (*i.e.*, analytical reagents and research chemicals); (2) medicinal (or pharmaceutical) chemicals; (3) photographic chemicals; together with other groups according to taste.

It is now well known that whereas before the war the manufacture of certain fine chemicals was satisfactorily established in this country, in the large sense, the fine chemical industry was essentially German. There was no organised industry and no organisation of manufacturers. To-day the Fine Chemical Group of the Association of British Chemical Manufacturers is numerically the strongest and possibly the most active in the Association.

The outbreak of war rudely awakened the country to the fact that fine chemicals are products of national importance, and, incidentally, that war cannot be waged without them, so that many and many a substance which we had until then contentedly bought from Germany had to be manufactured hurriedly with inappropriate plant and almost regardless of cost. Some of these were wanted for the immediate purposes of war, others for the manufacture of munitions, yet others for their medicinal properties. Arrangements prompted by the action of the Institute of Chemistry and the Society of Public Analysts were made for the supply of analytical reagents of requisite and known purity. More recently the manufacture of research chemicals has been systematically undertaken, and is now approaching a satisfactory condition. Good headway has been made by the makers of photographic chemicals, and also by those of synthetic perfumes and essences. The manufacture of medicinal organic synthetic products has made very considerable progress; those begun early have been improved, perfected, and stabilised; and many others have been added or were in course of being added when the present *impasse* arose. It is much to be able to say that we have never gone short of essentials. British manufacturers have proved that they can

turn out products of first-rate quality. Economy of manufacture, maximum yields, with corresponding reduction of costs, were following in due course, slowly, it is true, but nevertheless surely.

Rome was not built in a day. To train up an army of skilled organic chemical workers requisite to the fine chemical industry is a matter of years.

The British fine chemical industry—as we now understand it—had to be initiated under war-time *i.e.*, the worst possible conditons. The early post-war period afforded manufacturers the first opportunity to stabilise their immature efforts, but it was then that they experienced to the full the difficulties of obtaining plant and erecting buildings, long delays and high prices being the prominent features. The efforts of the industry—a new one— to expand were hindered by the dead weight of the excess profits duty. Yet, despite all the enormous difficulties, progress on the whole was really good until the Sankey judgment, like a bombshell, completely changed the situation. This, helped by the anomalous position of foreign exchanges, has led to the swamping of the market with German goods, a combination of circumstances which threatens defeat unless the Government steps in promptly and redeems its pledge to protect "key" industries.

Fine chemical manufacturers after very full consideration, have unanimously pronounced in favour of prohibiting imports of fine chemicals except under a system of licences, which should readily be granted when British manufacturers are unable to meet genuine demands for essential products. This, it will be seen, is precisely similar to the course it is proposed to adopt in the case of dyes: a natural coincidence when it is borne in mind that the fine chemical industry and the dye industry are indissolubly linked together and must inevitably go hand-in-hand. Indeed, one of the less obvious, but by no means negligible, features of the fine chemical industry is that it elaborates the otherwise useless by-products of the dye industry, thereby giving employment to thousands of men. Incidentally, it affords a training ground for chemists, technical and industrial, which no other school can rival.

An amendment to the Dyestuffs (Import Regulation) Bill was designed to exclude from the provisions of the Act "synthetic organic products imported mainly for medicinal or surgical purposes." This attitude on the part of some of our legislators does not augur well for the safeguarding of the organic chemical industry, nor for the future of the Empire. It is, indeed, a very short-sighted policy which seeks to gain a small, problematical, and temporary reduction in the cost of a certain number of medicinal substances at the expense of losing an industry already half-established, and which if fully develloped would make the nation permanently self-supporting in the production of curative agents. Moreover, the Bill provides for the importation under licence of substances which cannot be produced at home. It is this kind of opposition, born in ignorance and nourished in apathy, which confronts those who have the national welfare at heart. It is to be feared that there are others remaining in the background and doing their work covertly, who are directly concerned that England shall *not* have a fine chemical industry, and who are doing all in their power to let her sink back to her pre-war dependence upon Germany.

The many uses of fine chemicals in peace time, which justify so fully the claim of the industry to be regarded as a "key" industry, do not need to be laboured here. Research chemicals for our universities and teaching institutions, together with analytcal reagents for the same purposes and for works' laboratories, have already been mentioned. The importance of the industry to medicine and national health is not confined to the supply of synthetic drugs, but rests also upon the fact that the expansion of an organic chemical industry is intimately associated with developments in biochemistry and in the most modern methods of treating and preventing disease.

It cannot be too frequently nor too cogently insisted upon that the nation which possesses fine chemical and dye industries possesses potential arsenals for waging war, so that the nation which does not possess them is ever at the mercy of nations which do.

The present critical position of the fine chemical industry is largely due to the lack of confidence which manufacturers have in the Government. To-day it is not too late to save the situation; soon it will be.—*Journal of Society of Chemical Industry*, December 31, 1920.

PROCEEDINGS OF SOCIETIES.

FARADAY SOCIETY.

Monday, December 13, 1920.

SIR ROBERT HADFIELD, Bart., F.R.S., President, was in the Chair.

DR. A. E. OXLEY communicated and initiated discussion on a paper presented by Prof. E. D. CAMPBELL (University of Michigan), entitled, "*A Force Field Dissociation Theory of Solution Applied to Some Properties of Steel.*"

The author considers that understanding of the properties of alloys has been obscured by the use of the term "solid solution" and by expressing constitution in terms of percentage weights. There is no essential difference between a liquid and a solid solution, and the constitution of both should be expressed as molecular or atomic concentrations per unit volume.

The electrolytic dissociation theory in its usual form is inapplicable to alloys. The force field force field theory, however, put forward simultaneously by Baly and the author is a modified form of it which is applicable to liquid and solid solutions alike. The assumption is made that in a molecule the electromagnetic force field associated with the constituent atoms is closed in the combination but in solution this force field is more or less opened out by the solvent, to an extent depending on concentration and composition. The reactivity of ions is due to the open force fields and not to the presence of electric charges. In the presence of an impressed e.m.f. the resultant of the reactivity is electrical resistance in the case of metallic solutions, electrical conductance in aqueous solutions.

Dr. A. E. OXLEY considered that the field force theory alone was insufficient to account for the

properties of solutions, the conceptions of Arrhenius were also required, otherwise Bragg's lattice structure did not apply. The union of two like atoms to form a molecule required that the electrons should be in ring or vortex motion or otherwise act as a magnetic unit or magneton. The Rutherford-Bohr, or "solar-system," atom did not explain the diamagnetic or paramagnetic properties of matter. Dr. Oxley went on to explain Langmuir's cube theory of atomic structure. His own theory might be supplementary to that if Langmuir's stationary electrons were made to describe a small orbit or be vortical in character.

The CHAIRMAN hoped Dr. Oxley's theory would prove to explain the remarkable magnetic properties of alloy steels and the phenomena of hardening.

Dr. OXLEY, in reply to a question, thought his conception could be made to fit in with spectral phenomena.

"The Electrical Resistivity of Dilute Metallic Solutions." By A. L. NORBURY, M.Sc.

It is well known that the small quantities of imprities in solid solution cause a large increase in the electrical resistvity of a pure metal. Data are collected showing the relative atomic effects of such impurities and a certain relationship appears to be brought out by doing so. The paper is divided into three sections.

Section I.

The general theoretic interpretation of data obtained by measuring the electrical resistivity of alloys is discussed.

(*a*) In the case of duplex alloys in which the componet metals are mutually insoluble and crystallise sde by side each crystal grain may be considered as a separate conductor. In so far as the arrangement of the grans tend to be in the nature of conductors arranged in parallel the conductivity will be a linear function of the composition. In so far as they tend to be arranged in series the resistivity will tend to be a linear function of the composition.

(*b*) In the case of alloys which form a continuous series of solid solutions the atomic effects of the metals on one another are approximately represented by the initial slopes of the observed curves on either side.

(*c*) Reasons are given for thinking that the initial additions of solute normally cause a linear increase in the resistivity of the metallic solvent.

(*d*) Temperature seems to affect the resistivity of solid solutions as if it were made up of two independent quantities of which the increased resistivity—consequent on solid solution formation—is very little influenced.

(*e*) Cold-work and variations in grain size have relatively small influences on the resistivity in the case of pure metals. In the case of duplex alloys the grain size has an increasingly large influence as the number of atoms forming the crystal boundaries becomes comparable with the total number of atoms present. The fall in resistivity consequent on tempering martensitic steel is discussed. It is suggested that in martensite the carbon is present in a highly dispersed condition, but is not in true solid solution in the α-iron.

Section II.

Data are collected showing the effects of various elements on the electrical resistivities of iron, nickel, palladium, platinum, copper, silver, gold, magnesium, cadmium, sodium, and potassium. The atomic effects of the solutes are plotted against the positions in the Periodic Table—the results bring out the general relationship that the atomic effect of a solute on the resistivity of a metallic solvent is large or small according as the solute is far from or near to the solvent in the Periodic Table.

Section III.

In this section the results are discussed.

(*a*) A comparison with the atomic volumes, intrinsic pressures, electrical resistivities, thermoelectric properties and decomposition potentials of the elements concerned shows that none of these atomic properties can be directly applied to explain the results. It is suggested that the atomic effects are small when there is little electrical attraction between the atoms of solute and solvent and large according as the electrical attraction between the two is greater.

(*b*) It seems probable that in the dilute solutions quoted the atoms of solute are not associated.

(*c*) Assuming, for example, the face-centred cube lattice in a dilute solid solution, a natom of solute will be surrounded by twelve equidistant atoms of solvent and will not be attached to any one of these atoms in particular. It will, therefore, exert attractive forces on the electrons of the surrounding atoms.

(*d*) It is generally assumed that metals conduct the electric current by means of their "free" electrons, the presence, therefore, of forces restraining the "free" electrons in solid solutions will account for their diminished conductivity.

Annual General Meeting, December 13, 1920.

The following Officers and Council were elected to serve for the coming year:—

President—Prof. Alfred W. Porter, F.R.S.
Past-Presidents—James Swinburne, F.R.S., Sir Richard Glazebrook, K.C.B., F.R.S., Sir Robert Hadfield, Bart., F.R.S
Vice-Presidents—W. R. Cooper, Prof. C. H. Desch, Dr. J. A. Harker, O.B.E., F.R.S., Emil Hatschek, Prof. T. M Lowry, C.B.E., F.R.S., Dr. E. H. Rayner, Dr. G. Senter.
Treasurer—Robert L. Mond, R.R.S.E.
Council—Dr A. J. Allmand, Dr. H. Borns, Prof. W. C. McC. Lewis, Harold Moore, O.B.E., Prof. J. R. Partington, C. C. Paterson, O.B.E., Prof. A. O. Rankine, Sir Robert Robertson, F.R.S., Sir T. Kirke Rose, Dr. W. Rosenhain, F.R.S.

In proposing a vote of thanks to the retiring President, Sir Robert Hadfield, who had guided the Society during the whole critical period of the war, Prof. Porter referred to the growth that had taken place in the Society's work and in its prestige during that period. He remarked that of the twenty-six General Discussions that had been organised by the Society, many of them in cooperation with other societies whose collaboration was greatly appreciated, no less than nineteen had been held during Sir Robert Hadfield's presidency.

CORRESPONDENCE.

THE PEOPLE'S UNION FOR ECONOMY.

To the Editor of the Chemical News.

Sir,—On July 16 last we wrote a letter on the extreme gravity of the financial position of this country, which you were good enough to publish. We were glad to observe the gradual awakening of interest in this matter, and the attention which all sections of the community are beginning to pay to the critical state of affairs. In order to promote further the views we expressed in July last the People's Union for Economy have now established their headquarters at 1, King's Buildings, Millbank, Westminster, S.W.1.

The People's Union for Economy will aim at keeping a watchful eye upon all Government expenditure with a view to directing attention to overlapping and waste in the administrative sphere. For this purpose it will operate through a strong Parliamentary Committee including members of all parties and of both Houses of Parliament, and they will seek to co-operate with other Associations working for the same objects. The Central Office aims further at becoming a bureau of information where all Parliamentary papers and estimates will be critically examined and filed for reference. It will be in constant touch with commercial and industrial bodies, individual economists and others in all parts of the country, with a view to providing the best possible material for criticism.

It is obvious that an organisation of this kind, which we believe to be without parallel in the country, must rely for its development upon the support of the public, whose interest it is solely designed to serve. We therefore invite all those who agree with the views we have expressed to give us their support by joining the Union, and by supplying reliable information of any instances of public waste and extravagance.

Forms of membership may be obtained on application to the Hon. Secretary, Mr. Leslie Hore-Belisha, 1, King's Buildings, Millbank, S.W.1.—

We are, &c.,

Salisbury	C. W. Bowerman
Askwith	J. W. Wilson
Midleton	Richard A. Cooper
Emmott	F. D. Acland
Oswald Mosley	Walter Leaf
Godfrey Locker-Lampson	Leslie Hore-Belisha
Islington	

Mr. Eric Tomkinson makes the following addition to his letter on "The Colour of Water' inserted in last week's issue :—

"It should be remembered that the molecular formula of water, determined from surface tension measurements, was found by Ramsay and Shields (*Zeit. physikal Chem.*, 1893, xii., 464; *Journ. Chem. Soc.*, 1893, lxiii., 1089) to be $(H_2O)_4$ at 0°."

Halogen Derivatives of Lead and Thallium—They should, it appears, form well defined combinations. By varying the ratio of the two compounds in a mixture of Tl and Pb, in aqueous solution, M. Barlot successively isolated $PbBr_2$, TlBr, PbI_2Tl and $TeClPbCl_2$.—*Comptes Rendus*, October 21, 1920.

NOTES.

Royal Institution.—On Tuesday next (January 18), at three o'clock, Sir G. P. Lenox-Conyngham will give the first of two lectures at the Royal Institution on "The Progress of Geodesy in India"; on Thursday (January 20), Dr. Arthur Harden begins a course of two lectures on "Biochemistry (Vitamins)"; and on Saturday, January 22, Dr. P. C. Buck commences a course of three lectures on the "Madrigal : Rhythm—Key—Technique," with musical illustrations by the English Singers. The first Friday evening Discourse on January 21, will be delivered by Sir Frank Benson on "Shakespeare and Democracy"; and on January 28 by Sir James Dewar on "Cloudland Studies."

£20,000 for Industrial Harmony.—Of the many New Year honours conferred by His Majesty none was more deserved than the Baronetcy bestowed upon Col. Sir Wm. Dupree, J.P., D.L., who, early in the great war, foresaw that one of the greatest problems that would evolve from the conflict, and which would shake nations to their foundations, would be the question of relationship between employers and employed. Events that have happened in all countries of the world during the last twelve months have clearly proved the wisdom of Sir Wm. Dupree's judgment of what would be the trend in industrial matters. Serious though the situation has occasionally been in England, this country has happily been spared the terrors of civil strife, and it can with all deference be said of Sir Wm. Dupree, as of other like public-spirited men, that his broad-minded munificence and indefatigable energy have contributed materially to the factors which have enabled England as far to avoid the industrial rocks and snags on which she would undoubtedly have foundered. So keen was Sir Wm. Dupree on what he felt to be his duty to his countrymen in this connection that in December, 1918, he approached the Rt. Hon. G. H. Roberts, M.P., who was then President of the Industrial League, and placed in his hands for the use of the League, and without any reservations whatever, a cheque for £20,000.

The Action of Copper on Moulds.—The existing opinion in favour of the employment of anticryptogamic bouillies is based upon the theories of Millardet applied to hydrated copper oxide. Continuing the studies already submitted to the Academy, M. and Mme. Villedieu demonstrate that the metal Cu is not more toxic for Peronospoaceæ than for moulds, and that vine stocks are not protected against mildew, although sufficiently bathed with ammoniacal nitrate to find the metal in the ash from tissue of the leaves. Thus it seems possible to replace copper in the mixtures hitherto employed by some less expensive elements.—*Comptes Rendus*, October 18, 1920.

Action of Selenium on Moulds.—The experiments of Messrs. Nemec and Varchav Kàs related to various varieties of *Mucdineæ* sown in a Raulin liquid modified according to their specific needs and mixed with seleniate of sodium. The influence of Se was especially notable with P. *Roqueforti*, but in the case *P. Candidum*, the metal apparently becomes toxic when the percentage exceeds a certain limit.—*Comptes Rendus*, October 18, 1920.

TRACES OF BROMINE.—The reaction proposed in 1912 by Messrs. Denigès and Chelle, according to the indications of Lebeau, is somewhat modified by M. Damiens, and sensitiveness becomes such that by a simple colorimetric method, after oxidation of iodine in form of iodic acid, it attains 1/6,000,000.—*Comptes Rendus*, October 20, 1920.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

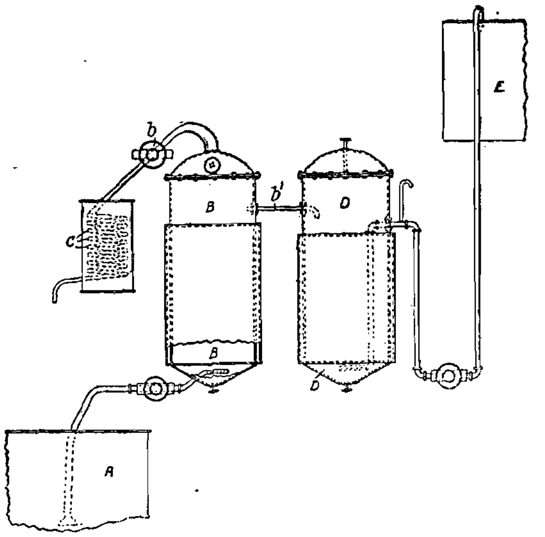
35853—Fyfe, A. W.—Manufacture of 1 chlor-2-amino-anthraquinone Dec. 21st.
35876—Rollason, A.—Production of Ammonia. Dec. 22nd.
36081—Starrels, J.—Process for producing fatty acids of high melting point. Dec. 23rd.
35970—Stockholms Superfosfat Fabriks Aktiebolag—Method of Manufacturing acetaldehyde from acetylene. Dec. 22nd

Specifications Published this Month.

155313—Rollason, A.—Production of ammonia.
155319—Moore, T. S.—Reduction of substituted nitro compounds, nitroso, and azo compounds.
155373—Arrowsmith, H. T.—Manufacture of acid pots to be employed in the production of white lead.
148579—Sudfeldt & Co.—Process for obtaining the salts of sulpho acids and alkyl-sulphuric acids from acid resins.

Abstract Published this Week.

Mr. C. J. Robins of Hull has obtained a Patent for means and apparatus for recovering the acetic acid, methyl alcohol, and acetone formed by the destructive distillation of wood in suction gas plants, No. 152420. The wash-water from the suction gas scrubbers



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is passed over chalk or barium carbonate until a sufficient concentration of acetate is obtained, and at the same time the methyl alcohol and acetone are withdrawn by means of vacuum. The wash-water contained in the tank A is pumped into the vessel B, provided with a heating jacket, where it passes through lumps of calcium or barium carbonate, and overflows through the pipe b1 into the vessel D, which also contains calcium or barium carbonate and is fitted with a cooling jacket. The methyl alcohol and acetone are drawn off from the heated wash-water in the vessel B by means of the pump b into the condensing coil C. The liquid issuing from the vessel D is pumped into the tank E, from which it can be run back to the scrubbers of the suction gas plant. The process is repeated until the content of calcium or barium acetate is sufficient to justify its recovery by evaporation.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK.

Monday, January 17, 1921.

Royal Society of Arts, 8. "Aero Engines," by Alan E. L Chorlton.

Tuesday, January 18.

Royal Institution, 3. "The Progress of Geodesy in India," by Col. Sir Gerald P. Lenox-Conyngham.
Society of Chemical Industry. (At Edinburgh).
Mineralogical Society, 5.30. "The Olivine Group," by A. F. Hallimond. "A method of rock-analysis diagrams based on statistics," by W. A Richardson. "Identity of Trechmann's 'B-tin' with Stannous sulphide," by L. J. Spencer. "Linarite, Caledonite, and associated minerals from Cumberland," by G. F. Herbert Smith. "On the Adare and Ensisheim Meteorites," by G. T. Prior.
Institution of Petroleum Technologists, 5.30.

Wednesday, January 19.

Royal Society, 4.30. "The Magnetic Mechanical Analysis of Manganese Steel," by Sir Robert Hadfield, S. R. Williams and I. S. Bowen. "A selective hot Wire Microphone," by W. S. Tucker and E. T. Paris. "Siren Harmonics and a pure tone Siren," by E. A. Milne and R. H. Fowler. "On the Design of Diaphragms capable of continuous Tuning," by Prof. L. V. King.
Royal Society of Arts, 4.30. "The Future of Industrial Management," by F. M. Lawson.
Royal Microscopical Society, 8.

Thursday, January 20.

Royal Institution, 3. "Biochemistry (Vitamins)," by Dr. Arthur Harden.
Institution of Mining and Metallurgy, 5.30.
Chemical Society, 8.

Friday, January 21.

Royal Society of Arts, 4.30. "Indian Timbers," by R. S. Troup.
Royal Institution, 9. "Shakespeare and Democracy," by Sir Frank Benson.

Saturday, January 22.

Royal Institution, 3. "The Madrigal—(1) Rhythm," by Dr. Percy C. Buck.

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3062, December 6th, 1918.
3063, December 20th, 1918.
3064, January 3rd, 1919.
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3068, January 31st, 1919.
3069, February 7th, 1919.
3070, February 14th, 1919.
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THE CHEMICAL NEWS.
VOL. CXXII., No. 3171.

THE STORING OF LIGHT.

(A HISTORICAL REVIEW OF INORGANIC PHOSPHORESCENCE.)

By J. FREDERICK CORRIGAN.

NO department of history can offer a more peculiar and fascinating study than that which deals with the introduction of mankind to the natural phenomena, and which traces the early struggles and progress of a crude science founded on mystery and superstition, towards the elucidation of the problems of nature. The histories and legends of kings and princes, fair maidens and chivalrous knights, of fearsome monsters and enchantments give, it is true, a thrill of pleasurable excitement to the reader, but in all of them something is lacking—an undefinable something which is ever present in the romance of the eternal quest for truth. A romance, however, which under certain aspects is pathetic, tinged with sorrow and with blighted hopes; a story of the struggles of early man against darkness and mystery, and with the crude ineffective tools of his own forging. Every new idea, every newly-discovered fact is an additional step forward along the lonely tortuous road which marks the path of science. But at what cost is each advance made? At the expense of almost Herculean effort, heroic self-sacrifice, and untiring devotion.

Phosphorescence, as a natural phenomenon, is widespread. It occurs in various guises, both in the living and in the mineral world. Its first introduction to mankind would most probably take place in the remote age when some poor rude uncivilised man was first frightened out of his wits on noticing the luminous appearance of decaying animal matter. This phenomenon he would ascribe to the "soul" of the animal rising forth to reveal itself to him, and subsequently luminescence would always be associated with the supernatural.* A phosphorescent object would be regarded as being

"Luminous, gemlike, ghostlike, deathlike."†

In the same way, the first prehistoric savage, who, on dipping the oar of his primitive canoe into the placid tropical waters and finding that it emerged irridescent, shining with a pale ghostly light, would doubtless have had the phenomenon of phosphorescence very forcibly impressed upon him. And then, as time went on, luminous flying-insects and beetles would be noticed, although as yet fire would be an unheard-of thing. Needless to say, these insects would be invested with a soul and would be preserved as sacred.

This is borne out by the fact that the earliest records of phosphorescence occur in the early Eastern manuscripts, where reference is made to the sacred insects of the Temple, which in the darkness shone with a light of their own. Biblical allusions to gems which shine in the dark may also occasionally found.

* Even at the present time, "apparitions" are invariably associated with luminous phenomena.

† Tennyson: "Maud."

Pliny was acquainted with the luminous appearance of decaying animal and vegetable matter. He also refers to certain precious stones which shine in the dark. It is customarily supposed, however, that apart from these few observations of Pliny, the phenomenon of phosphorescence did not attract much attention until the mediæval discoveries of the various "phosphoruses." It is more probable that the 16-17th century discoveries of the phosphorescent alkaline-earth sulphides were merely *rediscoveries* of facts known long before the Christian era. Such circumstances are not wholly unknown to science.

A strong point in favour of this view is found in Berthelot's discovery in certain 13th and 15th century manuscripts of various translations of Greek alchemical writings. Amongst them, Berthelot found recipes explaining methods of "colouring artificial precious stones, emeralds, carbuncles, hyacinths, according to the book taken from the shrine of the Temple." The authority of several alchemical writers is quoted, including Agathodemon, Democritus, and Ostanes, and a close study of the writings leaves no doubt as to the acquaintance of the ancients with methods by which stones could be rendered phosphorescent simply by coating them with a thin layer of a substance already phosphorescent.

Further evidence may be also obtained from Livy (xxxix., 13): "Matronas Baccharium cum ardentibus facibus decunise ad Tiberium demissoque in aquam faces, quia vivum sulphur cum calce insit intergra flamma efferre."

Which, with a certain ease of translation, may be rendered: "The Bacchantes would run down to the Tiber with burning torches, and plunging them into the water, would take them out with the flame unextinguished because they were covered with a mixture of living lime and sulphur."

Thus it is apparent that even the phosphorescence of calcium sulphide was known centuries before it was "discovered" by Marggraf in 1750.

Passing rapidly over a gap of nearly a thousand years, during which time the knowledge of phosphorescent substances appears to have been completely lost, we find at the beginning of the 16th century, Benvenuto Cellini in his "Art of Jewellery" putting on record the fact that some precious stones had been observed to shine in the dark; also the observation of Albertus Magnus, that diamonds when moderately heated, became luminous.

However, the first discovery which attracted the then rising scientific attention was that of Vincenzo Cascariolo, a cobbler of Bologna, who, in 1639 (according to some authorities, 1602) noticed that when a particular kind of earth found in the neighbourhood was heated in a certain manner, it acquired the remarkable property of emitting a soft, ghostly light after a certain amount of exposure to the rays of the sun. This substance was called by its discoverer *lapis solaris*, and on account of its power of attracting and storing up the golden rays of the sun, it was considered by Cascariolo to be nothing less than the long sought for Philosopher's Stone. The *Bologna Stone* was treated as a discovery of the greatest import. Learned treatises where written on the subject by the philosophers of the day, amongst whom were F. Licetus, a professor of philosophy at Bologna,

Celias, Potterius, and Kircher. Frequent attempts at its chemical analysis were made; speculations as to its nature and origin were entertained, but with little success. Science was not yet sufficiently free from the fetters of alchemy to enable any real progress to be made.

About this time (1669), Brandt of Hamburg had discovered phosphorus, by distilling a mixture of concentrated urine and sand, at a red heat. Being the possessor of business instincts as well as of alchemical attainments, he jealously guarded the secret of the preparation of the *Phosphorus Mirabilis*, and it was only after some time that he sold the secret to Krafft for a considerable sum of money. Krafft brought the phosphorus over to England, where the specimens exhibited created an enormous sensation. A new zest was added to the production of phosphorescent bodies, and the secret of the preparation of *Brandt's Phosphorus* was much sought for. Eventually, however, Kunkel (1678) and Boyle (1680) succeeded in effecting a preparation by means of methods similar to that of Brandt.

Boyle was also attracted to the study of other forms of phosphorescence. He had observed that diamonds gave out light when heated or rubbed, and in 1663 he investigated the phenomenon of the phosphorescence of decaying organic matter. Beccarius also made a searching examination of various substances, and he claimed to have found that "almost everything in nature imbibes more or less light, and emits it again in the dark." He divided bodies into several classes as they were phosphorescent "with or without preparation." Almost all vegetable and animal substances, when perfectly dry, he considered to possess this property, which was particularly well exhibited in the case of paper.

In 1677, G. A. Baldwin, of Misnia, whilst engaged in a search for the Philosopher's Stone, discovered that the product obtained by dissolving chalk in nitric acid, shone brightly in the dark, after exposure to sunlight for a few minutes. Great interest was again aroused by this discovery, and Baldwin, who was formerly a bailiff, found himself suddenly raised to the rank of an honoured philosopher. In a letter to the Royal Society (*Phil. Trans.*, 1676, ii.), he says: "This phosphorus contains the real spark, yea the most secret soul of the fire and light of nature, and consequently the innate and invisible fire of the philosophers; attracting magnetically the visible fire of the sun, and afterwards emitting and diffusing in the dark, the splendour of the same."

The discovery of Baldwin's phosphorus was particularly welcome, as the preparation of the Bolognian stone had been kept more or less secret. The new discovery, however, threw some light on the matter, and it was followed some little time afterwards (1764) by the discovery of *Canton's phosphorus*. Canton prepared his phosphorus by calcining oyster shells with sulphur, and it is to his credit that he was really the first who attempted to systematically investigate the phenomenon. He found that the phosphorus could be made to shine by heating it, after its spontaneous phosphorescence had ceased. He devised experiments whereby the intensity of the light which excited the phosphorescence could be compared, and he also noted that the phosphorescence took place

water appeared to have some action on the substance.

On the analysis of Bologna stone and its identification as a sulphide of barium by Marggraf (1750), and because of the progressively increasing scientific methods displayed in investigating the phenomenon, the preparation of phosphorescent substances became more frequent, and many were the uses to which these bodies were put. *Homberg's phosphorus* ($CaCl_2$) was sold in phials and used for illuminating the dials of watches and timepieces in the dark. Celestial objects, such as Saturn and his ring,* the phases of the moon, &c., were represented by cutting the object in wood and smearing the surface of it with a paste composed of equal parts of the white of an egg, and (Canton's Phosphorus) (Priestley's "History of Light and Colours," 1772).

In addition to the phosphorescence of the alkaline-earth sulphides, by means of which the sun's rays were seemingly absorbed and stored up, other types of phosphorescence began to be discovered. Reference has already been made to Boyle's observations on the phosphorescence of diamonds when heated or rubbed. In 1705, Francis Hawkesbee observed that friction between two glass surfaces "in common air, in the vacuum of an air pump, or under water" produced "a very considerable light." Du Fay noticed that some substances "shone with unusual splendour while they were dissolving, and thereby heated, in water; but this did not continue long." D. Hoffman discovered that certain felspars were luminous when rubbed together, and Pott added flints, certain crystals, and porcelain to the list of substances which gave out light when rubbed. Thomas Wedgwood, however, is generally credited with the discovery of "Luminosity by Attrition." In an extended paper on "The Production of Light from Different Bodies, by Heat and Attrition (*Phil. Trans.*, xvii., 128, 215), he separated substances into:—

(*a*) Bodies giving out light on warming.

(*b*) Bodies evolving light on attrition.

With regard to the former class, he found that the substances were by far the most luminous when they were first heated; that the duration of the light produced varies to a large degree, in some cases being almost momentary, and in others lasting for several minutes. Bodies of the latter class he found to be only luminous when rubbed. As soon as the rubbing was discontinued, the luminescence disappeared. Wedgwood was also the first to point out the yet unexplained fact that bodies emit a peculiar odour on attrition. He found it to be most persistent when the friction was greatest, and also to be independent of the light produced, as it was often present when the light emitted was practically nil.

But here we must draw a close to this brief sketch of luminescence throughout the ages. After the time of Wedgwood, the chain of observations and discoveries, never markedly coherent, becomes hopelessly broken and entangled in the oncoming tide of the scientific revolution which began about this period. In conclusion, however, a few remarks on the early theories of phosphorescence may be opportune.

Evelyn in his "Diary" (1650) refers to phosphorescent powders and preparations as a means

of "bottling up sunlight." This observation, probably given out with cynical intent, contains the gist of most of the early theories, and even now there remains much to be said in favour of it. Phosphorescent substances or "light magnets" as they were often called were considered to act as veritable *light-accumulators*, rapidly absorbing light, and afterwards emitting it gradually when placed in the dark. Priestley, in his "History of Light and Colours," says: "The hypothesis of the materiality of light is peculiarly agreeable to the phenomena of the Bolognian Stone, which has the remarkable property of imbibing light, of retaining it for some time, and of emitting it again; and more especally by its emitting it more copiously according to the degree of heat applied to it."

Not all the early experimenters agreed with this type of theory. On the other hand, Kircher put forward a theory in which he supposed that the air "abounds with a subtle vapour which is very easily illuminated." The phosphorescent substance absorbed this vapour (and presumably the illumination also) and gradually evolved it in the dark. But the theory of Kircher and similar ones however, were regarded as fantasies, and only the speculations based on the material nature of light made any progress—that is, if chemical theories *did* progress at all, in those days.

It is not within the scope of this article to enter into the modern theories of luminescence. Suffice it to say that they are all highly problematical and delightfully at variance with one another. Probably, however, in view of the modern tendency towards a material or semi-material conception of light and heat we may witness at some not long-distant date the absorption of all these varying and antagonistic hypotheses into one general, revived, and modified theory of *The Storing of Light.*

THE CHEMISTRY AND CRYSTALLOGRAPHY OF SOME FLUORIDES OF COBALT, NICKEL, MANGANESE AND COPPER.*

By FLOYD H. EDMINSTER and HERMON C. COOPER.

Introduction.

THE fluorides of the bivalent heavy metals such as cobalt, nickel, and copper, have never been fully investigated, neither have their composition and crystalline forms, including isomorphous relations, been satisfactorily established. An examination of the description of these compounds in the handbooks (*e.g.*, "Gmelin-Kraut") leaves one in doubt as to the facts and relationship.

In 1824 Berzelius (Berzelius, *Pogg. Ann.*, I., 1824, p. 28; *Ann. chim. phys.*, [2] 1823, xxiv., 61) prepared the fluorides of cobalt, nickel, and copper, and regarded them as so similar that he described them together. "If the carbonate (of the metal) is treated with hydrofluoric acid, it will dissolve with effervescence, but soon a salt is precipitated as a heavy powder. If more and more of the carbonate be added, the effervescence continues, but the salt already formed decomposes, especially if warmed, and there results a pulverulent basic salt. If the addition and decomposition of the carbonate be stopped before this salt (powder) forms and the solution be evaporated, there separates out a crystalline crust. . . . In this process there is given off the excess of acid which the dissolved salt contains. If the crystallised salt be covered with a very small amount of water and the mixture be allowed to stand for a long time at room temperature, there results a saturated solution which will deposit these same crystals on evaporation. If, however, the mixture is heated to boiling with much water, decomposition occurs, part of the salt dissolving in the liberated acid and another part remaining undissolved as a basic salt."

Berzelius selected the copper salt for anlysis, and found that on heating it with lead oxide there were given off two molecules of water, not in the least acid. The green pulverent salt resulting from the decomposition of the neutra lsalt by boiling water proved, by the same method of analysis, to be basic salt of the formula $CuO.CuF_2.H_2O$.

The three metals, cobalt, nickel, and copper, were thus regarded by Berzelius as forming entirely analogous fluorides; a crystallised normal fluoride, $MF_2.H_2O$, and an amorphous basic fluoride.

About fifty years later, F. W. Clarke (Clarke, *Am. Chem. Journ.*, 1887, xiii., 290) described the preparation of a supposedly new fluoride, made by evaporating a solution of nickel hydroxide in hydrofluoric acid, whereby a crystalline crust is formed. The analysis of this crust gave the formula, $NiF_2.3H_2O$.

In 1884, Balbaino (Balbaino, *J. Chem. Soc.*, 1884, ii., 1264) stated that he prepared the hydrated cupric fluoride ($CuF_2.2H_2O$) of Berzelius by dissolving copper carbonate in hydrofluoric acid and adding 95 per cent alcohol, which precipitated a pale blue crystalline powder.

Poulenc (Poulenc, *Compt. Rend.*, 1892, cxiv., 1426; *Ann. chim. phys.*, [7] 1894, ii., 47; *Ber.*, 1892, xxv., R. 662) is credited with the first description of the anhydrous fluorides. They are only of incidental interest to us here, but it may be noted that, according to Poulenc, the anhydrous nickel fluoride is formed as an amorphous yellow powder or as green crystallised prisms. The anhydrous cobalt fluoride is either a rose-red amorphous powder or red prismatic crystal.

In 1905, Böhm (Böhm, *Z. anorg. Chem.*, 1905, xliii., 330) reviewed the work on the fluorides of the heavy metals, called attention to the lack of accurate inevstigations of well-crystallised material, and prepared, along with several other complex fluorides, the acid fluorides of cobalt, nickel, and copper. He stated merely that he obtained these by dissolving the freshly precipitated hydroxides or carbonates of the metals in hydrofluoric acid and concentrating until crystals appeared. His cobalt and nickel fluorides are describe as, respectively, red and green prisms, having similar form and composition. They are stable in the air and easily soluble in water and dilute acids. The metal was determined by electrolysis from a sulphate solution, the fluorine by heating the salt with pure Iceland spar and the

*A more detailed account of this work was submitted to the Faculty of the Graduate School of Syracuse University by Floyd H. Edminster in May, 1918, in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

by heating a mixture of the salt with lead ate in a combustion tube. Böhm found the -fluoride crystals to be different from the in that they soon lose their water of cry-ion in the air and that they decompose etely when heated in a closed tube, water ydrogen fluoride escaping, while copper remains. In the case of copper fluoride the e was determined by neutralising with an of sodium hydroxide and titrating back standard hydrochloric acid. The formulas ed by Böhm for these fluorides are of a ly acid fluoride type.

Purpose of the Investigation.

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have undertaken a combined chemical and llographic study of these fluorides, not y to ascertain the facts in question, but to hether an isomorphous series is involved.

Preparation of Materials.

following general methods were investi- (1) Treating the hydroxide of the metal an excess of hydrofluoric acid. The excess cessary for avoiding the formation of the salt. (2) Decomposing the carbonate with fluoric acid. In either of these cases the ing solution is evaporated until crystals r. Both methods yield satisfactory results. "Dissolving" the metal in hydrofluoric acid. st cases the action was so slow that only a small concentration could be obtained. (4) ing a salt of the metal (the acetate) with fluoric acid. (5) Double decomposition of cali fluoride and a salt of the metal. A com-luoride resulted.

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this procedure resulted in the formation, not of crystals, but of a crystalline crust on the sides and bottom of the container and an arborescent creeping growth extending often over the sides of the vessel. The walls of the container and the dessicator were bedewed with a strongly acid solution, which was not absorbed by the sulphuric acid. If the evaporation took place in the open air, the crust was drier and harder and more difficultly soluble.

Under the microscope this crust looked different according to the conditions under which the evaporation took place. In some cases the crust was only a mass of nodules, while in others it appeared to be a mixture of amorphous material and of small but fairly definite crystals. In the case of copper the crust was, fortunately, almost wholly crystalline.

In view of the fact that the anlyses of Berzelius and Clarke were made on material prepared in this way, special attention was given to preparing a product which could be regarded as suitable for analysis, but examination with the petrographic microscope showed the preparations—except in the case of the copper salt—to be either amorphous and of indefinite water content or mixtures of amorphous and crystalline material. Analses of these products were made and indicated roughly a ratio of cobalt or nickel to fluorine of 1 : 2, but the character of the crystals was too indefinite to warrant careful investigation of their composition.

Recrystallisation.—If this crust is placed in about an equal weight of water, the crystalline portion can be seen to dissolve out, while the amorphous portion remains. If the amount of water is increased and the temperature raised, all of the material dissolves. Except in the case of cobalt no well-defined crystals, capable of measurement, were obtained from the original solution of the hydroxide in hydrofluoric acid. All of the crystals used for analysis and measurement have been obtained from the water extract of the crystalline crust, the extract being allowed to evaporate slowly in the air. Even then some of the crust is nearly always formed around the crystals and a second recrystallisation is necessary to free them entirely from the crust. Each recrystallisation reduces the acid concentration until in the third is practically negligible.

We hesitated to recrystallise from pure water because of the possibility of hydrolysis and, particularly, because of the possible loss of acid in case the salts should be acid fluorides, as our investigation as well as Böhm's disclosed. Contrary to expectations, the proportion of amorphous

water by heating a mixture of the salt with lead chromate in a combustion tube. Böhm found the copper-fluoride crystals to be different from the others in that they soon lose their water of crystallation in the air and that they decompose completely when heated in a closed tube, water and hydrogen fluoride escaping, while copper oxide remains. In the case of copper fluoride the fluorine was determined by neutralising with an excess of sodium hydroxide and titrating back with standard hydrochloric acid. The formulas assigned by Böhm for these fluorides are of a strongly acid fluoride type.

Purpose of the Investigation.

It is hardly possible that the conclusions of Berzelius, Clarke, and Böhm can all be correct, since all of them offer different formulas for salts prepared by methods which should yield the same type of fluoride for a single metal. It is reasonable to suspect that the old master, Berzelius, drew too hasty conclusions from his brief experiments.

Notwithstanding the slight experimental foundation on which the existence of the normal fluorides is based, one is inclined to prefer a normal salt formula to an acid salt formula for a halide obtained from the hydroxide or carbonate and acid, because it is in this way that the most familiar normal chlorides and bromides are prepared.

We have undertaken a combined chemical and crystallographic study of these fluorides, not merely to ascertain the facts in question, but to see whether an isomorphous series is involved.

Preparation of Materials.

The following general methods were investigated. (1) Treating the hydroxide of the metal with an excess of hydrofluoric acid. The excess is necessary for avoiding the formation of the basic salt. (2) Decomposing the carbonate with hydrofluoric acid. In either of these cases the resulting solution is evaporated until crystals appear. Both methods yield satisfactory results.

(3) "Dissolving" the metal in hydrofluoric acid. In most cases the action was so slow that only a very small concentration could be obtained. (4) Treating a salt of the metal (the acetate) with hydrofluoric acid. (5) Double decomposition of an alkali fluoride and a salt of the metal. A complex fluoride resulted.

The first general method was ordinarily employed. The hydroxides were precipitated from the acetate solution with sodium hydroxide, the precipitate being washed repeatedly by decantation with cold water and finally with hot water, until the filtrate gave no colour with phenolphthalein. The washing must be very thorough, since the gelatinous hydroxide adsorbs the alkali greedily. An excess of alkali was avoided and the precipitate was heated in an excess of water to boiling repeatedly before bringing it upon the filter. The moist hydroxide was then dissolved in C. P. hydrofluoric acid in a platinum basin and the solution was filtered through a wax funnel into a wax bottle, from which it was taken as needed.

Böhm specifies that the solution should be evaporated in a vacuum dessicator over sulphuric acid until crystals appear. Attempts to follow this procedure resulted in the formation, not of crystals, but of a crystalline crust on the sides and bottom of the container and an arborescent creeping growth extending often over the sides of the vessel. The walls of the container and the dessicator were bedewed with a strongly acid solution, which was not absorbed by the sulphuric acid. If the evaporation took place in the open air, the crust was drier and harder and more difficultly soluble.

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We hesitated to recrystallise from pure water because of the possibility of hydrolysis and, particularly, because of the possible loss of acid in case the salts should be acid fluorides, as our investigation as well as Böhm's disclosed. Contrary to expectations, the proportion of amorphous material lessened, rather than increased, with decreasing acidity, indicating that it is not a basic salt. The acid concentration, however, appears to control the equilibrium involving the crystal and amorphous phases.

Preparation of Cobalt Fluoride.—Our first preparation of cobalt fluoride was by treating the hydroxide with hydrofluoric acid. Because of the tendency of the cobalt (ous) hydroxide to oxidise in the air during the long washing process to cobaltic hydroxide, wihch is insoluble in hydrfluoric acid, we generally used the carbonate instead. It is permanent in the air, filters more quickly and is more easily washed. It is, however, less soluble than the cobaltous hydroxide. To be sure, the carbonate, when added to the

hydrofluoric acid, is decomposed as long as there is any acid present, but, as Berzelius stated, there is precipitated a fine rose-red powder, which is dissolved only upon the addition of more acid and water.

The original solution was evaporated on a water-bath until solid appeared, whereupon it was removed to a heat-insulated box of the Swedish box, or fireless cooker type, and allowed to cool slowly. No crystals formed. Even after standing in the box until half of it had evaporated, the solution continued to yield a brittle crystalline crust, the last portion being the same as the first.

The next trial was made in the open air, using the mother liquor from this crust, but no real crystals were obtained. The same method was tried, starting with a dilute solution and allowing it to evaporate slowly at an even temperature, with no better results. Böhm's method of letting stand in an evacuated dessicator over sulphuric acid was then tried. The evaporation proceeded slowly because, as stated above, the escaping vapour was not absorbed by the sulphuric acid but condensed upon the inner wall of the dessicator. Solid fluoride formed upon the sides of the basin and then crept over the edge. Under the microscope this crust appeared to have no crystal form and no definite composition.

The cobalt fluoride crust, however formed, is slowly soluble in very dilute hydrofluoric acid. For this reason a few drops of hydrofluoric acid were added to the water on dissolving. Upon evaporation the same results were obtained as in the first evaporation. Since the crust appeared to consist of more than one form of material, differing in solubility, a comparatively large amount was treated with a small quantity of water and warmed. The filtered solution upon standing for six hous began to deposit crystals which, though accompanied by crust, were sufficiently distinct from it to be separated mechanically. When these crystals were recrystallised from slightly acid water, very clean, well-defined crystals were obtained.

Preparation of Nickel Fluoride.—For the preparation of nickel fluoride either the hydroxide or the carbonate may be used, since the hydroxide, unlike that of cobalt, is stable in the air. The first product was a crystalline crust, as for cobalt. The crust forming on the surface of the evaporating solution is identical in appearance under the microscope with that deposited on the bottom. Satisfactory crystals were obtained in the same way as for cobalt, the cleanest ones resulting from a second recrystallisation from water.

Preparation of Manganese Fluoride.—Of all the fluorides investigated that of manganese is the most difficult to prepare. The hydroxide is less stable in the air than that of cobalt; so that, before it can be thoroughly washed, much of it has become insoluble in hydrofluoric acid; but a more serious difficulty is the comparatively slight solubility of the manganous hydroxide in hydrofluoric acid. The carbonate likewise dissolves only to about 10 per cent; further addition of the carbonate produces a marked effervescence and the precipitation of a fine powder, which does not dissolve upon the addition of more acid and water. The solution of the fluoride is consequently very dilute.

If the manganous fluoride solution be heated on the water-bath, the fluoride precipitates as the powder, so that all evaporation must be done at room temperatures, requiring on the average six weeks to produce crystals. The crust also forms as in the case of cobalt and nickel, but decomposes when digested with water. We attempted to obtain manganese fluoride by dissolving the metal in hydrofluoric acid, but obtained only manganese dioxide, which was formed by an unusually vigorous reaction between the metal and acid.

Preparation of Copper Fluoride.—For the preparation of copper fluoride the hydroxide is to be preferred to the carbonate, since the hydroxide reacts faster with hydrofluoric acid. Although it forms a basic salt upon standing in the air, the product is soluble in more acid. If the copper fluoride solution be evaporated slowly, small irregular blue crystals form on the bottom of the basin; while, if the evaporation takes place on the water-bath, the fluoride appears as a clear crystalline crust of constant composition. Both the small crystals and the crystalline crust were free from the granular, amorphous material so persistent in the deposition of cobalt and nickel fluorides. They were regarded as sufficiently well defined for analysis. The analyses showed the two products to be identical in composition, viz. to be a normal fluoride.

These normal fluoride crystals are difficultly soluble in water, a white coat forming upon the surface. If an excess of water is added and the solution is heated, the filtrate yields upon evaporation well-defined three- or sixsided prismatic crystals. These are very soluble in water and, strange to say, have the composition of an acid fluoride. On exposure to the air they effloresce rapidly. If they are heated, water and hydrogen fluoride are evolved, leaving copper oxide in the tube. Presumably the hydrogen fluoride is driven off first, whereupon the water of crystallisation hydrolyses the copper fluoride.

Observations on Dissociation.

The crystal fluorides of cobalt, nickel, manganese, and copper all evolve hydrogen fluoride when exposed to the air. After a portion of one of these substances is washed and dried and set aside on the watch glass the latter is found to be etched in three minutes. The gradual loss of hydrogen fluoride is a very important property of these fluorides. It means that the compound cannot be preserved with certainty of its retaining its original composition and that analyses must be made with the freshest possible product This phenomenon will be referred to the discussion of the analysis. It would be interesting to determine the rate or decomposition, but no work has been done upon it thus far.

The cystals are soluble in water and dilute acids. When heated, they give off water and hydrofluoric acid and are themselves converted to the oxides, as stated by Böhm, for the copper salt.

Analysis of the Fluorides.

For the *metal* the following general methods are applicable: (1) precipitation as the hydroxide or sulphide with subsequent reduction in a stream of hydrogen; (2) evaporation with sulphuric acid

and weighing as the anhydrous sulphate; (3) heating at red heat to convert the fluoride into the oxide; (4) electrolytic deposition.

The *total fluorine* can be determined volumetrically by adding an excess of standard alkali and titrating back with standard acid. In this case the precipitated hydroxide is filtered off before the titration, else it will obscure the end-point. With nickel and copper, using phenolphthalein as an indicator, a very good end-point can be obtained if the alkali be added slowly to the warm solution until the free hydrofluoric acid is neutralised and the hydroxide of the metal is precipitated.

The gravimetric determination of fluorine is based upon its precipitation as an insoluble fluoride. A number of metals form insoluble fluorides, calcium being the one most commonly used. Lead chloride precipitates the fluorine as the double halide, PbFCl (G. Starck, *Z. anorg. Chem.*, 1911, lxx., 173; *J. Chem. Soc. Abs.*, 1911, c., ii., 436), and lithium chloride is said to give accurate results (Deladrier, *J. Chem. Soc.*, 1904, lxxxvi., 440). In our work with the fluorides lead chloride gave results uniformly low and lithium chloride failed in some cases to give a precipitate The difficulties of precipitation are well known. Calcium fluoride is an extremely finely divided, slimy precipitate, which passes through nearly all filters the first time. Refiltering through the same filter proved to be exceedingly tedious, and washing was impracticable because of the time consumed in filtration of the solution. However, a number of determinations for fluorine were made by precipitating it with calcium chloride or calcium acetate. While the results were not accurate, they afforded independent confirmation of those obtained by other methods so far as the interpretation was concerned.

The purpose of adding the carbonate to the fluoride in the calcium fluoride method (Berzelius) is to assist in the filtration. A modification of this procedure has given good results in our work. Instead of adding sodium carbonate we made the solution slightly acid with acetic acid. An amount of standard ammonium oxalate was then added so that the calcium oxalate precipitated would be approximately the same as the weight of calcium fluoride. The two precipitates were then filtered off together in a Gooch crucible, dried and weighed. The difference between the weight of the combined precipitate and the weight of the calcium oxalate, corresponding to the ammonium oxalate added, gave the calcium fluoride. The decided advantage lies in the elimination of the decomposition, and furthermore, it does not necessitate a second filtration. The calcium oxalate serves the same purpose as the calcium carbonate and does it equally well. None of the absorption methods was used in the analysis for fluorine.

The determination of *crystal hydrate water* is the most difficult, since a temperature sufficiently high to expel the last traces will cause a loss of at least a part of the hydrogen fluoride. The method used by Böhm—heating the fluoride with lead oxide—is the only one described as being satisfactory. In the analyses that follow the water determinations were so variable that they were used only as rough indications of the amount present. For calculating formulas use was made of the percentage of water by difference.

(To be continued.)

THE MOLECULAR STATE OF WATER VAPOUR.

By JAMES KENDALL.

Up to a few years ago it was universally considered that water vapour at ordinary temperatures was, so far as could be deduced from vapour density determinations, entirely monomolecular H_2O and obeyed the gas laws within the limits of experimental error. Regnault's measurements gave 18·0 for the molecular weight, Gay-Lussac's 18·01 and Leduc's 18·1, while the formula H_2O requires the value 18·016 (Abegg, "Handbuch der anorganischen Chemie," [1] 1908, ii., 67). In the derivation of equations for osmotic pressure, vapour pressure lowerings, &c., in dilute aqueous solutions, the assumption was accordingly made, without any question, that water vapour could be treated as a perfect gas. Some measurements by Winkelmann (Winkelmann, *Wied. Ann.*, 1880, ix., 208) appeared to indicate a tendency towards association at temperatures slightly above normal, but even as late as 1907, in a discussion at the Faraday Society (Wilsmore, *Trans. Faraday Soc.*, 1907, iii., 85) the different results quoted for saturated vapour at 15° varied more among themselves than from the theoretical value, and the conclusion that the vapour behaved as a perfect gas was undisputed.

In 1908, however, some calculations were published by Bose (Bose, *Z. Elektrochem.*, 1908, xiv., 269), based upon new vapour density determinations by Kornatz (Kornatz, *Inaug-Diss.*, Königsberg, 1908), claiming that association in the saturated vapour was considerable even at ordinary temperatures. The equilibrium $(H_2O)_2 \rightleftarrows 2H_2O$ was assumed to exist in the vapour phase and an equation for the variation in the equilibrium constant with temperature was derived. This equation indicated for the saturated vapour at 0°, 6·6 per cent association; at 50°, 8·2 per cent association; at 100°, 8·9 per cent association.

In 1915, Oddo (Oddo, *Gazz. chim. ital.*, [1] 1915, xlv., 319), evidently ignorant of the work of Bose, calculated from the tables of Landolt-Börnstein ("Tabellen," 1912, p. 369) (Regnault's data, reproduced from Zeuner's "Technische Thermodynamik") the molecular weight of saturated water vapour between —20° and 200°, obtaining values steadily increasing from 17·03 at —20° to 19·92 at 200°. Only at 32° did the experimental value agree with that required by monomolecular H_2O. The conclusion was drawn that at temperatures below 32° a *dissociation* equilibrium, $H_2O \rightleftarrows H^+ + OH^-$, existed, and above 32° an *association* equilibrium: $(H_2O)_2 \rightleftarrows 2H_2O$. At —20° the degree of "ionisation" was calculated to be 5·79 per cent; at 200° the "association" reached 19·11 per cent. Great emphasis was laid upon the former phenomenon—*the spontaneous ionisation of water vapour*—as opening up a new field in science, and in a second article (Oddo, *Gazz. chim. ital.*, [1] 1915, xlv., 395) remarkable deductions were drawn therefrom upon such diverse topics as atmospheric electricity, the influence of temperature on vegetation, the respiratory processes of plants and animals, the electrolytic reactions in a monocellular organism, and

* Presented at the Buffalo Meeting of the American Chemical Society, April 10, 1919.

the first experimental mechanism for the origin of life.

An adequate discussion of so many important questions cannot be entered into here, but since the molecular weight of water vapour is a matter of fundamental interest in a few minor fields (such as the modern theory of solutions and steam engineering practice) it has been thought profitable to subject the mutually contradictory conclusions of Bose and Oddo to a critical examination, particularly since these conclusions are now quoted without reserve in standard monographs (Turner "Molecular Association," 1915, p. 89). The results below 32° may first be considered.

According to Oddo, saturated water vapour below 32° is partly dissociated into hydrogen and hydroxyl ions. At 0° the calculated degree of ionisation is 2·6 per cent, the vapour pressure being 4·6 mm. From these figures we can determine the concentration of hydrogen and hydroxyl ions in saturated vapour at 0°. The value obtained is 7×10^{-6} *g. ions per litre, in other words*, just 200 times as great as the corresponding concentration in pure liquid water at 0° (Kohlrausch and Heydweiller, *Z. physik. Chem.*, 1894, xiv., 317). Since the mobility of the ions in the vapour phase would certainly be enormously greater than in the liquid, owing to the diminished viscosity of the medium, it follows that the conductivity of saturated water vapour (or air saturated with water vapour) at 0° should be comparable with that of a fairly concentrated salt solution. Now this is admittedly not the case, hence Oddo's whole argument must be quite invalid.

The explanation is not far to seek. Regnault's data at temperatures below the normal (although smoothed off on a curve to render them consistent) are far too inaccurate to be employed as a basis for determinations of molecular weights to the second place of decimals. In fact, the density of the saturated vapour at pressures so low as 4·6 mm. becomes so small that it is impossible to measure it with anything approaching the above order of accuracy. Even the exceedingly careful determinations of Young (Young, *Proc. Roy. Soc.* Dublin, 1910, xii., 374) on the specific volumes of the saturated vapour of 30 organic liquids are conceded to be uncertain at the lower temperatures investigated, for this same reason. Consequently, until more definite proof of this spontaneous ionisation of water vapour is brought forward, we cannot consider the molecular weight of water vapour to be appreciably diverted from the normal value as a consequence of such ionisation. (The dielectric constant of water vapour is so near to unity as to appear to preclude more than the merest trace of ionisation--Bädeker, *Z. physik. Chem.*, 1901, xxxvi., 305).

It remains to examine the abnormally high vapour densities for temperatures above normal, upon which both Bose and Oddo postulate the equilibrium $(H_2O)_2 \rightleftarrows 2H_2O$. Bose's calculations are dependent entirely upon a series of 19 determinations at 13 different temperatures (T ranging from 50° to 182°, p ranging from 52·6 to 790 mm.) by Kornatz. It is true that a few isolated measurements of previous investigators are quoted, which are in fair agreement with these results, but of the many determinations which do not agree no mention is made.

While Kornatz's measurements certainly indicate a greater vapour density than the theoretical for monomolecular water throughout the whole series, yet examination shows that *at any one temperature* the observed variation in density with pressure is *systematically* different from that calculated by the use of Bose's equation for the equilibrium: $(H_2O)_2 \rightleftarrows 2H_2O$. The following table will illustrate this clearly. Densities are given relative to air; the theoretical ratio for monomolecular water is 0·6216.

T (abs.)	p (mm. *Hg.*)	Density (obs.)	Variation with p.	Density (calc.).	Variation with p.
348	86·8	0·6324	0·0095	0·6307	0·0139
348	231·5	0·6419		0·6446	
353	71·0	0·6308	0·0063	0·6276	0·0144
353	249·0	0·6371		0·6420	
358	86·76	0·6307	0·0052	0·6278	0·0116
358	260·3	0·6359		0·6394	
363	52·6	0·6286	0·0061	0·6247	0·0119
363	263·0	0·6347		0·6366	
368	63·4	0·6282	0·0051	0·6247	0·0091
368	253·6	0·6333		0·6338	

It will be evident from the above table that the observed variation is approximately only 50 per cent of the calculated. Bose remarks, in a passing comment on this fact, that it is possible that the experimental results are affected by systematic errors, which may be partially explained by assuming that the equilibrium $(H_2O)_2 \rightleftarrows 2H_2O$ in the vapour phase is only slowly established. It is extremely improbable that this assumption is correct, since even in liquid water no indication of anything but instantaneous equilibria between the different molecular species present has ever been obtained. If Kornatz's data *are* trustworthy Bose's interpretation of them is not justified; if they are *not* trustworthy, no such interpretation should have been attempted.

We are consequently left to face the fact that while vapour density measurements for temperatures above the ordinary give abnormally high results, these high results cannot be adequately explained by assuming association in the vapour phase. Indeed, other evidence renders it certain that such association is negligible even at 100°. Let us compare the abnormality in the density of saturated water vapour at this temperature with the abnormalities shown by the saturated vapours of other liquids at their boiling points. The data in the following table are taken from Washburn (Washburn, "Principles of Physical Chemistry," 1915, p. 31).

Liquid	Boiling point °C	Vapour density (observed/calculated)	Vapour density (observed/corrected)
Benzene	80·1	1·024	0·990
Pentane	36·3	1·046	1·002
Heptane	98·4	1·055	1·007
Chlorobenzene ...	132·0	1·055	1·019
Nitrogen ...	—195·7	1·05	1·00
Helium ...	—268·5	1·09	—
Water	100·0	1·028*	1·018†

* Value taken from Regnault's determinations see Oddo, *Gazz. chim. ital.*, [1], 1915, xlv., 328.

† Critical data employed were taken from Holborn and Baumann, *Ann. Physik.*, [4] 1910 xxxi., 945.

The ratios obtained in the third column show that all substances (even such generally accepted non-associated liquids as the saturated hydrocarbons and the inert gases) give saturated vapours of abnormally high density even at pressures as low as one atmosphere. As has been pointed out by Guye (Guye, *Trans. Faraday Soc.*, 1910, vi., 84), the assumption of the merest trace of association in the vapour phase involves extreme association in the more concentrated liquid phase, consequently if the above abnormalities are due to molecular complexity in the vapour state than even the so-called "normal" liquids are all exceedingly complex. While it would be going too far to state that we have *no* indications of association in the liquid state for the substances listed above, yet their general physical properties show conclusively that any deviations from ideality are very slight. (Dolezalek has recently claimed (*Z. physik. Chem.*, 1919, xciii., 585), that liquid argon is slightly associated, but rightly notes that such association does not extend appreciably unto the vapour phase).

To what, then, are the abnormalities due? To the simple fact that the saturated vapours under discussion do not exactly follow the gas laws, but require a correction according to the equation of state. When such a correction is applied (as has been done in the last column of the above table by means of Berthelot's modification of van der Waal's equation) the abnormalities practically disappear (see Washburn, *loc. cit.*, p. 33).

It will be noticed that water vapour diverges *less* than the "theoretical" than the majority of substances listed. Have we any more reason to attribute the abnormalities here to the presence of dimolecular $(H_2O)_2$ than we have to postulate polymerisation in pentane vapour or the existence of He_2 in helium gas? It is true that liquid water is highly associated, and that the vapours of certain similarly associated liquids such as acetic acid (Young, *loc. cit.*) show unmistakable association even at low temperatures, yet from the values obtained in the table above it is evident that, below 100° at least, association in water vapour can only be minute. While the observed vapour density is still slightly above the corrected theoretical value, yet the excess is not so great as in the case of chlorobendene and may be accounted for in part by uncertainty in the critical data. (If association exists at the critical point, the crtical data are not strictly applicable to the Berhelot equation). At temperatures approaching the critical, where the pressure is very high, association of the saturated vapour may become appreciable, but the extensive association claimed by Bose and Oddo at temperatures below the boiling point is certainly an exaggeration of the facts. (The experiments of Ramsay and Young (*Phil. Trans.*, 1892, clxxxiii., 107), indicate a rapid increase in the ratio (obs./calc.) above 200°. At 270° the observed vapour density is more than 15 per cent. in excess of the corrected theoretical).

In conclusion, it is necessary to record a protest against the optimistic habits prevalent among writers of text books as well as of original articles, of treating all gases as perfect. In work on gaseous systems, it is rare to find any correction applied for "the equation of state," although frequently intricate calculations which pre-suppose considerable accuracy are carried out with the use of the observed densities. In techncal processes (probably following Haber's "Thermodynamics of Technical Gas Reactions" and similar monographs) no regard at all is commonly paid to possible abnormalities, even when reactions under high pressures are considered. That the quantities of different gases introduced into the reaction vessels under such conditions are quite at variance from the correct proportions has been strikingly shown in recent work on the Haber process ("Physical and Chemical Data of Nitrogen Compounds," 1918, p. 5-6 (M.I.D. Research Laboratory, University College, London)). The extended discussion of this general question given by Lewis in several articles does not appear to have attracted the attention which it deserves (G. N. Lewis, *Proc. Am. Acad.*, 1901, xxxvii., 66, etc.; 1907, xliii., 262; *Journ. Am. Chem. Soc.*, 1915, xxxvii., 2309).

For the same reason, vapour density determinations upon dissociating substances, such as phosphorus pentachloride and the ammonium halides (Smith and Lombard, *Journ. Am. Chem. Soc.*, 1915, xxxvii., 38, 2055), will not furnish exact values for their dissociation unless correction is made for the appreciable divergence from the perfect gas laws of all of the substances concerned in the equilibrium. The possible error in functions derived from *variations* in the calculated degrees of dissociation (such as the heat of dissociation) will naturally be much greater (Smith and Lombard, *loc. cit.*, p. 55). To attempt to obtain quantitative values for the association of *liquid* water from uncorrected vapor density measurements, as has been done by Guye is obviously altogether futile (Guye, *Trans. Faraday Soc.*, 1910, vi., 84).

In the standard Victor Meyer vapour-density experiment the text-books on practical physical chemistry "allow" the student an error of "less than 5 per cent," although the abnormalities in the vapour densities of many common liquids exceed that value. Since corrections of less than 1 per cent (*e.g.*, for the water vapour content of the atmosphere) have been proposed (Evans, *Journ. Am. Chem. Soc.*, 1913, xxxv., 958), it would evidently be well worth while to introduce the equation of state factor into the discussion. Otherwise, the accurate student and the conscientous instructor will inevitably clash, without prospect of reconciliation.

Summary.

The monomolecular nature of water vapour has recently been questioned, "spontaneous ionisation" of H_2O into H^+ and OH^- at low temperatures and association into $(H_2O)_2$ at higher temperatures being postulated. It has been shown here that the evidence for the existence of the equilibria

$$H_2O \rightleftarrows H^+ + OH^- \text{ and } 2H_2O \rightleftarrows (H_2O)_2$$

is in each case entirely insufficient, that the abnormalities in the vapour densities of normal substances at their boiling points are similar to that in water vapour at 100°, and that such abnormalities practically vanish on applying the corrections for deviation from the perfect gas laws.

An "equation of state" correction is similarly necessary in gas reactions at high pressures, in calculations on dissociation in the vapour state and in Dumas or Victor Meyer vapour-density determinations.—*Journal of the American Chemical Society*, December, 1920.

THE DEVELOPMENT OF THE CHEMICAL INDUSTRY IN THE FORMER PRUSSIAN POLAND.

The chemical industry in that part of Poland which was known before the war as Prussian Poland gives signs of a sound and remarkable development. Its productivity has been recently extended in the field of the chemical by-products of alcohol. The distilleries of Posen and Pomerania have been united in a big concern "Akwawit Rectification of Alcohol and Chemical Factory." The head office of this new Company is in Poznan (Posen).

Considering the natural wealth of this province of Poland as regards alcohol, high hopes are entertained that the exports of its by-products will contribute considerably to the improvement of the economic position of the country in the international market.

The Company has acquired all the distilleries situated in Poland, belonging to the firms C. A. F. Kahlbaum of Berlin, and Breslauer Distillery of the Charlottenburg Company. The subscribed capital of the "Akwawit" Company amounts to 20,000,000 marks. The chief subscribers are The Land Bank of Posen (2,500,000 marks), The Kwilecki Potocki & Co. Bank (2,500,000 marks), The Co-operatives Union Bank (1,000,000 marks), The Commercial Bank of Posen (11,700,000 marks), C. A. F. Kahlbaum (2,000,000 marks).

The Board of Control consists of 18 members; among them there are eight landowners and five bank directors.

A few more facts pointing to the development of the chemical industry deserve some attention.

A new chemical factory has been founded in Glowno near Posen; it is called "Posen Chemical Works of K. Chmielewski." Another big concern founded in May, 1920, known as the "Luban Potato By-Products Factory" has published a report which shows that up to September 30, 1920, its net profits amounted to 3,719,423 marks. This Company has already acquired the starch factory in Torun (Thorn) which belonged to the German concern known as "Deutsche Bruder Unitat in Herrnhut," and it proposes to buy out other German factories, situated in Polish territory, especially the branches of the famous German firm C. A. Kohlman & Co., of Frankfurt-an-Oder. The Luban branch of this firm is already run by the Polish "Luban Potato By-Products Factory" which has acquired the rights of tenancy.

These Luban factories producing potato meal, starch, dextrine, soluble starch, and potato pulp, constitute the biggest concern of this kind in Poland, and are capable of working daily 20 to 22 wagons of potatoes. Owing to the requisition of potatoes by the Food Ministry, the factories have been compelled to work only at short time. The greater part of the produced potato meal has been exported to France, England, and Germany, the rest has been used for home consumption. The lack of transport has made the exports very difficult. The exports for France have been transported by trains supplied by the French Mission.

The production of dextrine was possible, only on a small scale; it has been consumed chiefly by the textile industry in Lodz and Bielsk.

Owing to the devaluation of Polish money, high prices of raw materials, and rising costs of transport, the company proposes to raise its capital to 20,000,000 marks.

Similarly, the wholesale druggist factory in Posen has increased its capital to 15,000,000 marks.

The Pharmaceutical Products Factory "Bareikowski & Co." shows a net profit for the year 1919-1920 of 987,000 marks. Out of this amount 400,000 marks have been given away for social purposes. This factory has increased considerably its activity through opening branches in Gdansk (Danzig) and Warsaw. Its capital has been raised to 15,000,000 marks.

A factory of matches ("Zygaunt Stabrowski") has been started in Posen; a company has been formed in Bydgoszcs (Bromberg) with the view of starting another factory of matches, the subscribed capital amounts already to 3,000,000 marks.

The relation between imports and exports may be shown as follows:—

For the period of July 1, 1919 to January 1, 1920, the imports of chemical products into Poland amounted to 9,000,000 marks, and for the period from January 1, 1920 to October 1, 1920 to 87,000,000 marks. The exports from Poland for the period from September 1, 1920 to January 1, 1920 amounted to 3,000,000 marks, and from January 1, 1920 to October 1, 1920 only to 609,000 marks.

COLOUR TEST FOR OXALIC ACID.

By LEWIS H. CHEINOFF Denver, Colo.

A few crystals of resorcinol are added to about 5 cc. of the unknown solution in a test tube, and the mixture is warmed slightly to dissolve the resorcinol. It is then cooled and 5 cc. of concentrated sulphuric acid is carefully and slowly poured in along the side of the tube so as to form a layer. A blue ring will be formed at the juncture of the two layers, if oxalic acid is present. The colour is best seen if held to the light in front of a sheet of white paper. Care must be taken that the mixture does not warm up appreciably. If the blue colour does not appear in a few minutes, the mixture is shaken thoroughly, and, after cooling somewhat, 5 cc. more of sulphuric acid is added. Should the colour still fail to appear, the mixed contents of the tube should be gently warmed over a flame (not boiled) when an indigo blue colour will diffuse throughout the liquid. If the mixture be cooled with ice-water, the colour will disappear only to reappear again on heating. If the mixture be boiled a few minutes, the colour will turn a deep dark *green*, which will become a light yellow-green on cooling. If to the cold yellow-green solution an equal volume of sulphuric acid be added so as to form two layers, the *blue* colour will again appear. It is believed that all these reactions taken together are characteristic of oxalic acid alone.

This test may be made sensitive to one milligrm. if the dry unknown substance be warmed with two drops of a 10 per cent aqueous resorcinol solution and the sulphuric acid added drop by drop. The blue colour then appears immediately. For very

dilute solutions of oxalic acid or its salts, it is best to evaporate to a concentration of about 10 per cent.

If interfering substances are present the oxalic acid may be precipitated in ammoniacal solution as the calcium salt, washed with water, and the test applied directly to an aqueous suspension of the salt.—*Journ. Am. Chem. Soc.*, Sept.

CORRESPONDENCE.

COLOUR OF WATER.

To the Editor of the Chemical News.

Sir,—With reference to my note on the above subject in your Journal of Jan. 7, 1921 (cxxii., p. 9), the second "Sir" in the first line should be deleted.

Bancroft also discussed (Chemical News, 1919, cxviii.) the question as to whether the colour of water is due to the scattering of light by sus pended particles. This subject has been studied recently by W. H. Martin (*Journ. Phys. Chem.*, 1920, xxiv., 478). He prepared dust-free water by distillation in vacuo, by precipitating gelatinous zinc, cadmium, and aluminium hydroxides from solution of the sulphates, and by cataphoresis of water (see *inter alia*, T. R. Briggs, "Second Rep. on Colloid Chem.," B.A., 1918, pp. 26-52; and also Ormandy, Somerville, and Northall-Laurie; Chemical News, 1920, cxxi., p. 14; and Ormandy, *ibid.*, p. 301).

Martin found that all the dust-free liquids which he examined scattered light, that of short wave length more than of long wave length. The intensity of the scattered light from dust-free water was found to be 0·06 (toluene = 1), a comparatively low value, that for, *e.g.*, α-chloronapthalene being 4·3. Martin also found that the scattered light is very largely plane polarised from liquids which scatter little light (*i.e.*, water) and the polarisation in different liquids decreases as the relative intensity of the scattered light increases, and he showed that phenomena which he observed are really ducto light-scattering and not to fluorescence (for recent work on this subject in connection with the gases H, N, air, O, CO_2, and N_2O (see Rayleigh, *Proc. Roy. Soc.*, 1920, xcvii., 485; Chemical News, 1920, cxxi., 42), and for He and Ar (Rayleigh, *Proc. Roy. Soc.*, 1920, xcviii., 57)).

Regarding the work of Ducleaux and Wollemann (see Chemical News, 1921, cxxii., 9) it is instructive to note that Ramsay and Shields (*Zeitschr. physikal Chem.*, 1893, xii., 464; *Journ. Chem. Soc.*, 1893, lxiii., 1089) from measurements of surface tension, found that the formula of water at 0° is $(H_2O)_4$. This to some extent confirms the hypothesis of Ducleaux and Wollemann, inasmuch as the formula of water is shown to be $(H_2O)_4$ at 0°, and a mixture of $H_2O.(H_2O)_2$ molecules at 100 (from vapour density of steam).—I am, &c.,

E. Tomkinson.

Walney, Barrow-in-Furness, 8th January, 1921.

NOTES.

British Industries Fair.—The arrangements are well in hand for the forthcoming British Industries Fair to be held at London (organised by the Department of Overseas Trade), and Glasgow and Birmingham. The London and Birmingham Fairs run concurrently from February 21 to March 4, while the Glasgow Exhibition opens a week later on February 28. Intending visitors will therefore have no difficulty in getting from one section to another. Only British manufacturing firms are allowed to show and the goods must be of the exhibitor's actual manufacture. The Glasgow Exhibition will have considerable interest for the chemical manufacturing trades, inasmuch as its schedule includes chemicals (heavy and light), domestic chemical products and dyes, while at London, places are given to drugs and druggists' sundries, photographic apparatus, scientific and optical instruments, and glassware of all descriptions. Manufactured metal goods, general hardware, guns, small tools, weighing instruments, and motorcycles and cycles will be important features at the Birmingham Fair, and a position of prominence is given to paints, colours, oils and varnishes and painters' requisites, and to nautical scientific instruments and apparatus. Lighting and heating appliances form a much larger section than last year.

Board of Trade Announcement.—In pursuance of the powers conferred upon them by Section 4 (1) of the Gas Regulation Act, 1920, the Board of Trade have appointed Sir R. T. Glazebrook, K.C.B., F.R.S., to be Chief Gas Examiner under that Act, and Mr. C. V. Boys, F.R.S., Mr. J. S. Haldane, F.R.S., and Mr. W. J. Atkinson Butterfield, M.A., F.I.C., F.C.S., to be Gas Referees. The Board have also appointed Mr. H. C. Honey to be Director of Gas Administration in the Power Transport and Economic Department, Board of Trade Offices, Great George Street, S.W.1. Furthermore, in pursuance of the provisions of Section 2 (4) of the above-mentioned Act, the Board have appointed Sir William Pearce, M.P. (Chairman), Dr. T. Carnwath, D.S.O., M.B., Mr. William Doig Gibb, O.B.E., M.Inst.C.E., and Dr. T. Gray, D.Sc., Ph.D., to be a Committee to enquire whether it is necessary or desirable to prescribe any limitation of the proportion of carbon-monoxide which may be supplied in gas used for domestic purposes, and also Mr James Hunter Gray, K.C. (Chairman), Mr. W. J. Atkinson Butterfield, M.A., F.I.C., F.C.S., and Dr. C. H. Lander, D.Sc., M.I.M.E., A.M.I.C.E., to enquire whether it is necessary or desirable to prescribe any limitations of the proportions of incombustible constituents which may be supplied in gas. Communications may be addressed to the Secretary to each of these Committees at the Power Transport and Economic Department, Board of Trade, Great George Street, S.W.1.

Hydrogen Peroxide and Flour.—The method employed to analyse catalase in milk by measurement of the volume of oxygen disengaged in contact with a certain quantity of hydrogen peroxide is applied by M. Marion to wheat flour. Thus the degree of purity can be determined and also that of milling.—*Comptes Rendus*, October 26, 1920.

CYANAMIDE AND DICYANAMIDE IN CALCIC CYANAMIDE.—The most frequent analyses of calcic cyanamide relate to (1) total nitrogen; (2) nitrogen of cyanamide; (3) nitrogen of the dicyanamid. Analysis of the total nitrogen is made by the Kjeldahl method. As for the cyanamide and dicyanamide nitrogen, analyses are based upon the following reaction. (1) Solution of calcic cyanogen gives with nitrate of silver and in presence of ammonia an argentic precipitate containing all the nitrogen of the cyanamide. (2) An aqueous solution of dicyanamide does not precipitate with nitrate of silver in presence of NH_3, but gives a precipitate when the ammoniacal solution is boiled with excess of NaOH or KOH. Thus an argentic precipitate of dicyanamide can be obtained with the ammoniacal mother liquor from precipitation of the cyanamide. Some authors (Kappen for cyanamide, and Ulpiani, dicyanamide) proposed an estimate of the silver in the argentic precipitates, with $AgNO_3$ and $CNSNH_4$. Confirming what had already been noted by Caro with argentic cyanamide, Messrs. Marqueyrol, Loriette and Desvergnes, noted that the silver in the argentic precipitates was in variable proportion for cyanamide, and that the argentic dicyanamide was particularly soluble in water. The only method which gives precise results is quantitative analysis of the nitrogen in the argentic precipitates, estimating from this analysis the percentage of cyanamide and dicyanamide.—*Bull. Soc. Chim. de France*, November 20 1920.

LINSEED OIL SUBSTITUTES.—The last number of *Revue de Chimie Industrielle* draws attention to an error they made in setting up the type, lines of one paragraph being mixed with another. It should read as follows from line ending "linseed oils":—"If one wishes to give siccative properties to non-siccatives such as fish oils it suffices to add varnish to them. The fish oil is first boiled in presence of the necessary metallic siccatives, then the hot linseed oil is poured slowly into it so that there will not be a fall of temperature. When fish oil is subjected to the action of ozonised gas in presence of spongy platinum they acquire siccative properties. A product is obtained similar to the lacquer of Rapolin by boiling thick oils (20 kilogrms. linseed oil and wood oil) with 10 of Brazil copal at about 280° C. The temperature is let fall to 160° C. and 50 grms. of flowers of sulphur added, 40 grms. paraffin; 110 grms. rubber solution; 60 grms. mirbane essence; 6 kilogrms. spirit of turpentine, and 6 of benzine." The last 18 lines belonged to another paragraph.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

36581—Anderson, J.—Fusion of organic substances with alkalies. Dec. 30th

36536—British Dyestuffs Corporation—Manufacture of oxy and sulpho-oxy derivatives of anthraquinone. Dec. 30th.

36377—Chemische Fabrik Flora.—Manufacture of silver thioglycolate of sodium. Dec. 29th.

36712—Cook, D.—Chemical and physical synthesic. Dec. 31st.

36476—Fitzgerald F. W. V.—Preparation of substitutes for vulcanite horn, etc. from blood. Dec. 30th.

36644—Moulin, R.—Apparatus for diffusion of essence or volatile liquids. Dec. 31st.

36465—Plauson, H.—Manufacture of phosphatic manures. Dec. 30th.

36558—Piauson, H.—Oxidation of acetaldehyde to acetic acid. Dec. 31st.

36286—Watson J.—Method of treating mineral stained barytes to produce a pure white. Dec. 29th.

757—Aschkenasi, L.—Manufacture of perborates and di-sodium-phosphates. Jan. 7th.

471—Blanc, G. A.—Extraction of Potash from leucite or leucite rocks. Jan. 5th.

121—Bleicen, B.—Apparatus for production of distilled water. Jan. 3rd.

515—Boocock, M.—Recovery of ammonia from ammoniacal-liquor. Jan. 6th.

414—Burke O'Donogon.—Manufacture of lithopone zinc sulphide and ammonia. Jan. 5th.

519—Deutsche Gold-und Silber-Scheideanstalt vorm Rossler.—Manufacture of acetone. Jan. 6th.

885—Norsk Hydro-Elektrisk Kvalstofaktieselskab.—Apparatus for effecting continuous crystallization of solutions Jan. 7th.

Specifications Published this Week.

155600—Head, C. J.—Method for the production of metallic tungsten power direet from sodium and potrasium tungstates.

155609—Sauer, J. N. A—Process for the purification and separation or filtration of liquids or liquors.

136061—Jaloustre, L. A. and Knifetz, Z. and Warchabsky, M.—Process for the production of condensation products of phenols and aldehydes.

155692—Hood, J. J.—Purification of Sulphur.

141059—Mrreau C. and Dufraisse, C.—Condensation products of acrolein with phenols.

126625—Desachy, P.—Process for the manufacture of anhydrous zinc sulphide.

137071—Norsk Hydro-Elektrisk Kvelstofaktieselskab.—Production of concentrated nitrous gases and nitric acid.

145732—Krupp Akt.—Ges. F.—Acid-resisting receptacles such as boilers, pipes and the like.

Abstract Published this Week.

Zirconium Salts.—Mr. H. Wade, of Hatton Garden has obtained a Patent No. 153113 for a new basic sulphate of Zirconium of the composition $5ZrO_2$, $3SO_3$, $13H_2O$ free from iron titanium, and silicon is obtained by adding sulphuric acid in the requisite quantity to a solution of zirconium oxychloride containing free acid preferably hydrochloride acid. The basic sulphate is precipitated on heating.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK.

Monday, January 24, 1921.

Royal Society of Arts, 8. "Aero Engines," by A. E. L Chorlton.

Tuesday, January 25.

Royal Institution, 3. "The Progress of Geodesy in India," by Sir Gerald P. Lenox-Conyngham.

Institution of Electrical Engineers, 7. (At Leeds).

Wednesday, January 26.

Royal Society of Arts, 4.30. "Origin and Development of the Research Associations established by the Department of Scientific and Industrial Research," by A. Abbott.

Society of Chemical Industry, 7. (At Nottingham).

Thursday, January 27.

Royal Institution, 3. "Biochemistry (Vitamins)," by Dr. Arthur Harden.

Institution of Electrical Engineers, 6. "Temperature Limits of Large Alternators," by G. A. Juhlin.

Friday, January 28.

Royal Institution, 9. "Cloudland Studies," by Sir James Dewar.

Physical Society, 5.

Institute of Metals, 7.30. (At Sheffield).

Saturday, January 29.

Royal Institution, 3. "The Madrigal (Key)," by Dr. P. C. Buck.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the Editor.

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THE CHEMICAL NEWS
VOL. CXXII., No. 3172.

CONSTITUTION OF MATTER AND ELECTRICITY*

By A. N. SRIVASTRA.

In this article the author hesitatingly attempts to express certain ideas regarding the structure of the atom and the constitution of matter and electricity, which, though in direct contradiction to the existing notions on the subject, might be of interest to some speculative minds. In this system of chemical philosophy, aether is believed to be the matter of matter and in it,

"Wrapt in mystic silence and gloom"
The slumbering secrets of creation lie."

Matter is aether condensed, and electricity is aether in motion. The electron at rest has no meaning, and it is motion that justifies its existence. The central nucleus is aether condensed, and thus excessively fine grained, capable of throwing out small particles, like the planets once shot from the sun. The electrons in the orbit are responsible for all the physical and chemical properties of the atom, and the phenomenon of radio-activity involves a derangement, both in the system of electrons and the central nucleus itself. The relative positions of the electrons, the diameter of their orbits, and their velocities, are determined by the charge of the nucleus and the field of force to which this charge gives rise. The number of electrons in motion round the positively charged nucleus in an atom is of the order of the half the atomic weight for the lighter elements. For an accurate determination of these numbers we are indebted to Mr. H. G. J. Moseley, but the evidence of his experiments is only comparative, not absolute. Thus, if the atomic number for hydrogen be n, for helium it is $n+1$, for lithium $n+2$, and so on. Moseley fixed the atomic number for hydrogen as 1, and then He is 2, Li 3, and so forth.

In the meantime, the existence of two light gases, coronium and nebulium, between hydrogen and helium, has been suggested by Rydberg. Prof. Rydberg, therefore, proposes that the atomic numbers be converted into ordinals by adding two units to all the elements but hydrogen. This would not, although, affect Moseley's data, but measurements of the scattering of X-rays by gases indicate consecutive numbers for hydrogen and helium. This difficulty can be overcome by placing the two hypothetical elements before hydrogen instead of after. This was the notion held by Mendeleeff. Coronium is his element, with an atomic weight ½, existing in the corona of the sun, and nebulium is his element. The aether, with an atomic structure and an insignificantly small atomic weight. As there seems to be no near possibility of other elements of low atomic weight, we may place aether as the element with zero atomic number (compare with Rydberg's electron gas). Coronium, on this table, will have an atomic number 1, and Moseley's numbers have to be increased by one unit.

Next turn to the question, the structure of the nucleus as understood by modern scientists. In connection reference may be made to an article by Prof. A. Berthond, that appeared in the April numbers of the Chemical News. Prof. Berthond states, "the positive charge of the nucleus does not represent merely the number of positive electrons which the nucleus contains. There is no doubt that the negative electrons also enter into its constitution. The apparent charge is determined by the number of positive electrons in excess as compared with the negative electrons. It is, however, probable that with hydrogen the atomic nucleus reduces to a single positve electron, the mass of which is 1830 times that of the negative electron." And further, "thus the positive electron reveals itself as the smallest corpuscle which enters into the constitution of matter, and at the same time as that to which bodies owe almost the whole of their weight." The positive electron is assumed to be the basis of all matter. Why then is the negative electron 1830 times lighter? It is a corpuscle of electricity, but with the thought as to the nature of electricity the professor is lost in the wilderness It has been loosely said, "Matter is an aggregate of positive and negative electricity." Still, the very fact that positive and negative electricity destroy each other renders such an idea inconceivable. Positive electricity is not the absence of negative electricity. The two are related like the positive and negative quantities in algebra. Thus, in our conception, as the negative electricity is produced by the motion of indefinitely small aether particles round the nucleus, at a tremendous in an anti-clockwise direction, the nucleus rotating round its axis in a clockwise direction generates positive electricity, and the two annul each other.

To our imagination the nucleus, therefore, appears as an aggregation of highly-condensed aether particles, which for some unknown reasons group themselves into hydrogen or helium nuclei on detachment from the parent nucleus. Another extract will illustrate the hopeless confusion and self-contradiction arising out of a belief in the positive electrons. Here is another quotation from Prof. Berthond: "Thus an electron appears as a corpuscle of electricity, devoid of any basis of matter; in the ordinary sense of the word it is at one and the same time the elementary particle of negative electricity, and an elementary particle of matter." In fact, it is a mistaken notion in science to identify electricity with matter. Matter and energy manifest in motion are two entirely different things, although both of them convey the idea of mass.

As a last point, it may be emphasised that the electrons which take part in a radio-active change seem to be those in the outer rings, as the transformation of an element is always accompanied by a change of valency, and the shifting of an electron from one ring to another liberates vast quantities of energy.

The idea enunciated in these columns gains additional strength on account of its similarity to known astronomical phenomena. Thus we may fancy the electron revolving round the nucleus, much in the same way as the earth does round the sun, and so forth. This is all but a hopeful speculation, and as such I commend it to our readers.

* Extract from a paper read before The Students' Society, Lucknow by the kind permission of Mr. M. P. Nigam, B.Sc., Secretary.

NOTES ON THE HIGH-LEVEL DIAMOND DEPOSITS OF BRAZIL.

By A. M. PONTIE, A.Inst.M.M.

Diamonds were first discovered in Brazil in 1729, at a place called Tijuca, in the State of Minas Geraes.

They are found in two distinct varieties of deposits:

1. In recent gravels, or ancient river terraces.
2. In high-level areas, which by many are thought to be conglomerates of fluviatile origin.

Many of the rivers of Brazil, though situated far apart, carry diamonds in greater or less quantities, the principal of these being:

The Jequitinhonha, near the town of Diamantina, Bagagem, Somno, Sao Antonio, Prata, Abaeté, Sao Francisco, in Minas, Paraguassú, in the State of Bahia, Tibaji, in Paraná, and many streams in Matto Grosso and Goyaz.

High-level diamond bearing deposits exist in many of the upper basins of these rivers; the best known are, Sao Joao da Chapada, Dattas, Serrinha and Bôa Vista, near Diamantina, Grao Mogol, about 120 miles further north, Agua Suja, near the town of Bagagem, and Lençoes, District of Bahia.

The majority of these high-level deposits are situated on the dividing ridges of the streams, several hundred feet above the present river valleys.

The discovery of diamonds in the high-level deposits dates from 1834, when an old slave woman found a large stone embedded in blue clay; this led others to investigate the formation, with the result that the locality, Sao Joao da Chapada has been worked for many years with very satisfactory returns.

For a number of years before this discovery, no attempt had been made to ascertain the source whence the diamond-bearing gravels of the rivers and valleys had acquired their precious stones. The great richness of these gravels, and the cheap slave labour, probably satisfied the then owners, and no doubt, lack of initiative and curiosity deterred them from studying the problem more fully. Prospecting in a country like Brazil is not at all easy; the lack of roads, the dense forests and thick undergrowth handicap the traveller, and the country is mostly covered with a thick coating of surface soil which obscures the underlying rock formation. Moreover, the insect pests which abound make the life of the explorer a perfect misery.

The most important high-level deposits so far located, are situated in the Serra do Espinhaço. This range of mountains extends northward from Ouro Preto to Joazeiro, a distance of about 620 miles, with a width of nearly 40 miles in its widest section. Some of the rivers rising from the higher eminences of this Serra have yielded the bulk of the diamonds.

The Serra do Espinhaço is flanked on the west by the valley of the Rio Sao Francisco, and on the east by the granitic and schistose foot hills, which extend to the Atlantic; the general altitude of the Serra is about 1500ft. above sea level, though many of the peaks rise to 4600ft.

* A Paper discussed at the Meeting of the Institution of Mining and Metallurgy, on Thursday, January, 20th, 1921.

The Serra is composed of a series of rocks, consisting of alterations of quartzites, with yellow and grey shales. These different beds occur throughout the series. The general dip of the strata is to the west towards the valley of the Sao Francisco, though it frequently alters and a reverse dip occurs. Where unweathered, the quartzites consist of a hard mass, made up of minute rounded grains of quartz, but where affected by considerable weathering, the quartzite is altered into soft sand-stone. The quartzites and sandstones are stratified and false bedded, the interbedded shales are laminated and generally slaty in structure. Quartz veins are abundant in both the quartzites and shales. Gold occurs in many of these veins. There are also thin layers of quartz conglomerates interbedded in the quartzites. The Espinhaço quartzite near the town of Diamantina, where extensive weathering has taken place, shows many lines of faulting, slightly inclined beds butting up against vertical or over turned strata. These phenomena are evidence of the enormous amount of pressure which must, at one time, have taken place.

The most important, though perhaps the least known, high-level diamond bearing deposits of the Serra do Espinhaço, are Serrinha, Bôa Vista, and Sao Joao do Barra.

The *Serrinha* deposit is situated eight miles south-east from the town of Diamantina.

This deposit lies on the crest of a mound, situated at the foot of a vertical cliff formed at this point by the uplifting of the Serra do Espinhaço.

The diamond-bearing ground covers an area of about half a square mile. Owing to lack of water on the ground and the altitude of the deposit, about 1000ft. above the river which flows at its base, regular and continuous work is not being carried out. The ground is well exposed by the existing cuttings and pits, in many places to a depth of over 40ft. On careful examination of the walls of these cuttings, it is evident that this deposit is a breccia consisting of boulders of soft sandstone, seldom more than a foot, or less than 3in. in diameter, angular in shape, with blunted corners. These boulders, some of which are flat and stand on edge, are embedded in a blue-grey mass, which contains a few rounded pebbles of quartz no doubt derived from the conglomerate beds in the Espinhaço quartzites. The boulders rarely touch one another, and are completely surrounded by the cementing mineral, which shows lines of schistose material curving round them. Small veins of iron oxide running through the mass are not uncommon.

The breccia has the characteristic of being able to stand in a vertical position. Clear faces 200 to 300ft. in length by 40ft. in depth, are exposed to view. The whole mass of mineral is soft, and readily disintegrates under the influence of a stream of water from a hydraulic nozzle, with 50lb. pressure per square inch.

Concentrates by jigging show the following minerals:

Magaetitie, small octahedra, abundant, sp. gr. 5·0.
Hematite, abundant, sp. gr. 4·5 to 5·3.
Martite, abundant, sp. gr. 5·2.
Pyrope garnets, rare sp. gr.
Some tourmaline and mica, rare, sp. gr. about 3·5.
Diamonds.

The diamonds are white and of very high quality, faulty stones being comparatively rare, under 2 per cent of the whole number. The small stones are valued locally at per carat, 4 and 5 carat stones are frequent, and there are very few under one-sixth of a carat.

Bôa Vista is situated 12 miles east from Diamantina and 8 miles south-west from Serrinha.

This high-level diamond-bearing deposit is in many respects similar to the one at Serrinha, except that the sandstone boulders are slightly smaller and a little softer. The cementing material, as far as can be ascertained by present indications, is of the same formation and constituency, but there is a considerable difference in the quality of the diamonds; they are, besides, on an average, smaller and contain a higher percentage of defective stones.

At one time this deposit was worked by a French company, but the then low price of diamonds and the extravagant management led to the inevitable financial failure, and lately a private firm worked the mine by very antiquated methods with satisfactory results. Within the last few months, an Anglo-Brazilian company has purchased the property, and are employing modern methods of extraction with gratifying results.

The area of the diamond-bearing ground is about two square miles. The deepest workings are down to over 100ft., without there being any indications of a change in the formation in the breccia. Tests made of the cementing material indicate that a large part of it was originally composed of olivine. So far, no olivine-bearing rocks have been found in the vicinity, though diligent search has been made in the district; it is, therefore, apparent that the cementing material in the breccia must be derived from some source other than the surrounding rocks.

Sao Joao do Barro is situated 20 miles north-west of Diamantina, and 12 miles north-west from Guinda railway station.

This deposit is the highest in the district, being 600ft. higher than the one at Bôa Vista, that is 5000ft. above sea level. This deposit in many respects resembles those at Serrinha and Bôa Vista, inasmuch as the breccia consists of angular boulders and slabs of very decomposed sandstone, with a few small pieces of shale and schist, derived from the immediately surrounding rocks. This formation is better defined than at the two above-mentioned localities. The deposit is surrounded on three sides by a well-defined and continuous ring of quartzite.

The area covered by the breccia is about one square mile. The deposit has been tested in several places to 150ft. in depth without showing any alteration or change in the minerals contained in the breccia. The cementing material is highly basic, containing talc and magnesia in very large proportions, but owing to the ring of hard quartzite surrounding the deposit, which retains the water collected during the heavy rains, the minerals in the breccia are decomposed to such an extent that they are barely recognisable, and until a greater depth is attained, it will be impossible to determine the various minerals which form the cementing mass.

This deposit has been worked for many years and has yielded the best quality of diamonds of the district. The stones are of a clear blue-white colour, and of good shape, and realise the highest price by weight for local diamonds.

Situated on the extreme eastern edge of the ring of outcropping quartzite is a cutting 1000ft. in length by 300ft. in width, with a depth of 150ft., exposing the different layers forming the last ring or wall of the breccia. The quartzites of the neighbourhood have a dip of from 15° to 20° East, but on the edge of the breccia at this point, the dip is 45° East, thus showing that at some period, local and violent disturbances have taken place, uptilting the strata at such an acute angle.

Origin of the High-Level Deposits of Diamantina.—Hitherto these deposits have been described as conglomerates of fluviatile origin, but aqueous conglomerates are totally different from those described at Serrinha, Bôa Vista, and Sao Joao do Barro. In river conglomerates the cementing material filling the interstices between the boulders contains a large percentage of the same material as the boulders themselves, and these consist of various kinds of rocks which are derived from the different strata through which the stream flows. Then again, the boulders are invariably rounded, except those which are derived from the rocks from the immediate vicinity, but the contrary is the case in the above high-level deposits, where the boulders are all of the same rock, whilst the cementing material is of a totally different nature from the boulders. Another cogent reason why these deposits are not of the fluviatile origin is that, in all such gravels and conglomerates, which contain minerals of higher specific gravity than the cementing material, local enrichment takes place, and rich shoots and pockets are formed; this is not so with the deposits in question, where the diamonds are found indiscriminately throughout the cementing mass, and not in patches or pockets. Another and very important point is that, local diamond merchants are able, at a glance, to distinguish parcels of diamonds derived from the various high-level deposits.

It is inconceivable that water could have transported and deposited boulders 1ft. or more in diameter and lodged them in a similar mass, and yet regulate the quality of the diamonds to such a nicety that they can be distinguished at a glance.

As the mass contains a considerable amount of olivine, it is obvious that these deposits must be derived from some deep-seated source, either through volcanic or thermal action. The former seems to be the more probable, especially since undecomposed Blue Ground "Kimberlite" has been discovered in Brazil in two different localities many miles apart. This with the above enumerated reasons makes it apparent that these high-level deposits are not conglomerates of fluviatile origin.

ROYAL INSTITUTION.—At the meeting of March 3, a Discussion on "Isotopes" will be opened by Sir J. J. Thomson, O.M., F.R.S.

THE PREPARATION OF SELENIUM OXYCHLORIDE.

By VICTOR LENHER.

THE first record in the literature that we have of selenium oxychloride is its preparation by Weber in 1859 (Weber, *Pogg. Ann.*, 1859, cviii., 615), who heated together in a knee-shaped tube the vapours of selenium tetrachloride and selenium dioxide. Michaelis prepared the oxychloride by the action of phosphorus pentachloride on selenium dioxide (Michaelis, *Ann.*, 1887, ccxl., 150). Later, in 1889, in their work on selenic acid, Cameron and Macallan mention that selenium oxychloride is formed when common salt is distilled with selenium dioxide (Cameron and Macallan, CHEMICAL NEWS, 1889, lix., 267).

The methods used in this laboratory for the formation of selenium oxychloride may be grouped under three heads.

1. *Direct Union of Selenium Tetrachloride and Selenium Dioxide at Room Temperatures.*

When elementary selenium is suspended in carbon tetrachloride and chlorine gas is passed in, the chlorine first dissolves in the carbon tetrachloride, this being an excellent solvent for chlorine at low temperatures. The dissolved chlorine immediately attacks the selenium, forming selenium monochloride which also dissolves at once in the carbon tetrachloride. Selenium monochloride, in turn, is an excellent solvent for elementary selenium. The solution and chlorination of the selenium is, therefore, much expedited.

An alternate method of preparing the two chlorides of selenium which possesses interesting advantages with certain selenium containing materials is to suspend them in carbon tetrachloride, chloroform, or similar solvent, and pass in chlorine. This converts the selenium first to the monochloride which is soluble in carbon tetrachloride while most of the metallic chlorides, being insoluble in carbon tetrachloride, can be at once removed by filtration or decantation, while the further chlorination of the selenium monochloride gives white selenium tetrachloride, which being sparingly soluble, separates out and if desired can be removed from the solvent by a second filtration.

To the suspended selenium tetrachloride in carbon tetrachloride it is convenient to add the calculated amount of selenium dioxide. Reaction takes place with formation of selenium oxychloride, which dissolves in the carbon tetrachloride. The liquid can then be distilled. Carbon tetrachloride distills at 76-77° and selenium oxychloride at 176·4°, hence they can be readily separated by distilaltion. Selenium oxychloride can be conveniently distilled under diminished pressure to a high degree of purity.

The carbon tetrachloride suggested in the above procedure can be replaced by chloroform or still better replaced by selenium oxychloride itself.

Inasmuch as selenium oxychloride is a solvent for elementary selenium, the entire operation of its formation can be accomplished by mixing together selenium dioxide and elementary selenium, treating this mixture with selenium oxychloride and then chlorinating.

2. *Partial Hydrolysis of Selenium Tetrachloride.*

This can be readily accomplished by treatment with water according to the following reaction.

$$SeCl_4 + H_2O — = SeOCl_2 + 2HCl.$$

This reaction can be carried out with solid selenium tetrachloride or with the selenium tetrachloride suspended in carbon tetrachloride, chloroform, selenium oxychloride or other liquids.

3. *Dehydration of the Compound $SeO_2 \cdot 2HCl$.*

This substance, first described by Ditte, can be formed by bringing hydrogen chloride into contact with selenium dioxide (*Ann. chim. phys.*, [5] 1877, x., 82). The two substances unite at moderately low temperatures to form an amber-coloured liquid of the formula $SeO_2.2HCl$. It is possible to remove the elements of water from this compound by means of phosphorus pentoxide, calcium chloride, or a similar dehydrating agent. The reaction can be carried out in the laboratory in one of two ways.

Selenium dioxide can be treated with hydrogen chloride, the resulting liquid mixed with excess of the dehydrating agent and the oxychloride distilled off, or selenium dioxide can be first mixed with the dehydrating agent and this mixture treated with hydrogen chloride. The operation can be conducted by either first passing hydrogen chloride into the mixture of selenium dioxide and dehydrating agent in the cold and subsequently heating to drive off the selenium oxychloride formed, or the mixture can be heated, hydrogen chloride passed in, and selenium oxychloride distilled from the hot mixture as it forms.

The author takes this opportunity of acknowledging the valuable help rendered by his assistant, Mr. A. J. Snyder, for various preparations of material in the above processes.—*Journal of the American Chemical Society*, December, 1920.

THE PREPARATION OF SOME HYDRAZINES.*

By LEONARD THOMPSON, M.Sc. Tech.

THE hydrazine compounds were discovered in 1871, in which year Strecker and Römer (*Ber.*, 1871, 784) prepared potassium phenyl hydrazine sulphonate, $C_6H_5NH.NHSO_3K$, by reducing diazobenzene nitrate with potassium bisulphite. E. Fischer (*Ber.*, 1875, 589) hydrolysed this compound and thus obtained phenyl hydrazine Phenyl hydrazine is generally prepared either by Fischer's method (*Ber.*, 1876, 1331) or by the method of Meyer and Lecco (*Ber.*, 1883, 2976, and 1884, 2972).

In Fischer's method, benzene diazonium chloride is converted into benzene diazosulphonate by pouring the diazo solution into a cold neutral solution of sodium sulphite. The diazo-sulphonate is most conveniently reduced by means of zinc and acetic acid. The solution of phenyl hydrazine sulphonic acid thus obtained is hydrolysed by hot concentrated hydrochloric acid, the phenyl hydrazine hydrochloride then being isolated and treated with caustic soda to give the free base. The yield of purified base is 60-65 per cent.

In Meyer's method a strong solution of benzene diazonium chloride is added to a cooled solution

* Read before the Manchester Section of the Society of Dyers and Colourists, November 19, 1920.

of excess of stannous chloride in concentrated hydrochloric acid. The tin double salt of phenyl hydrazine hydrochloride separates, from which the base is obtained by treatment with caustic alkali. The maximum yield stated is 85 per cent.

Phenyl hydrazine p-sulphonic acid.—This technically important derivative was first prepared by Strecker and Römer (*Ber.*, 1871, 784) by treating diazotised sulphanilic acid with potassium bisulphite and hydrolysing the resulting hydrazine sulphonate with hydrochloric acid. This method substituting sodium bisulphite, however, is used technically (*Annalen* 278, p. 297). Stannous chloride also brings about the reduction (*Ber.*, 1889, ref. 216), and sodium amalgam may be used to reduce the sodium iso-diazo salt (*Ber.*, 1897, 218). This hydrazine compound is also produced readily with quantitative yield by sulphonating phenyl hydrazine (*Ber.*, 1885, 3172; cf. also E. Fischer, *Annalen*, 1878, p. 76).

Para-nitro phenyl hydrazine.—This is one of the most useful of the hydrazine compounds and is largely replacing phenyl hydrazine itself, and the *p*-bromo derivative, for the preparation of characteristic derivatives of aldoses and ketoses owing to its stability and the greater crystallising power of its derivatives. *p*-Nitro phenyl hydrazine was first obtained by Purgotti (*Ber.*, 1892, 119), who used sodium bisulphite as the reducing agent. The general method of preparation is that of Bamberger and Kraus (*Ber.*, 1896, 1829), in which the neutralised concentrated diazo solution is poured into excess of neutral potassium sulphite, when *p*-nitro phenyl hydrazine disulphonate of potassium is produced. This is isolated, hydrolysed with hydrochloric acid, and the hydrazine base obtained by treatment with sodium carbonate and sodium acetate. The yield is given as almost quantitative.

Sodium sulphite may be used instead of the potassium salt, the method being described by Cohn (*Die Pyrazolfarbstoffe*), but this has several disadvantages.

Meta-nitro phenyl hydrazine.—This hydrazine derivative was first prepared and described by Bischler and Brodsky (*Ber.*, 1889, 2809), who obtained it by the reduction of meta-nitro benzene diazonium chloride with stannous chloride. The tin double salt of *m*-nitro phenyl hydrazine hydrochloride is produced, which is freed from tin by means of hydrogen sulphide. Yield, 50-60 per cent. The free base is obtained by treatment with sodium acetate.

The preparation by the sulphite method does not appear to have been fully investigated (see Hantzsch and Borghaus, *Ber.*, 1897, 89).

The hydrazine compounds enumerated above include the more important members of a class of compounds having numerous practical applications. Thus they are used in the manufacture of dyestuffs of the Tartrazine class, and in the identification and quantitative estimation of certain aldehydes and ketones, especially the carbohydrates. *p*-Nitro phenyl hydrazine has also been found to be a very useful reagent for the identification of oxycellulose, though it has been proved to be useless for the quantitative estimation of this substance. It was with a view to its use for this purpose, however, that the present work was undertaken. In view of the results already published (*Journ. Soc. Dyers and Colourists*, Aug., 1920) on the estimation of diazo compounds by reduction to the corresponding hydrazine compound, it was thought desirable to try other reducing agents, and of these sodium hydrosulphite and titanous chloride have been experimented with.

It is now found that phenyl hydrazine hydrochloride can be readily prepared directly by the reduction of benzene diazonium chloride with sodium hydrosulphite in presence of hydrochloric acid, according to the equation—

$$C_6H_5N_2Cl+2Na_2S_2O_4+4H_2O=$$
$$C_6H_5NH.NH_2.HCl+4NaHSO_3.$$

If solid sodium hydrosulphite be used for the reduction, the reaction is not quantitative, a small quantity of bright red compound being formed. This is presumably azo benzene *p*-hydrazine sulphonic acid, as observed by Grandmougin (*Ber.*, 1907, 858), who obtained in addition, a large proportion of diazoimides and sulphones, as well as the hydrazine sulphonate when carrying out this reduction with hydro-sulphite under different conditions.

The preparation of phenyl hydrazine can be carried out by using only one molecule of hydrosulphite, in which case the first product is phenyl hydrazine sulphonate of sodium. Besides being the cheaper process, this method gives a higher yield, as the volume of the solution is kept down to a minimum.

18·6 grms. of aniline are treated with 55 cc. of concentrated hydrochloric acid and 50 grms. of ice. The paste of aniline hydrochloride is cooled in a freezing mixture and diazotised with a cooled solution of 15 grms. of sodium nitrite in 30 cc. of water, a clear diazo solution being thus obtained. 46 grms. of hydrosulphite (80 per cent) is dissolved in 250 cc. of water containing a few drops of caustic soda to prevent decomposition, the solution being prepared in a stoppered flask of 250-300 cc. capacity. Both solutions are cooled to 0° C.; 20 cc. of concentrated hydrochloric acid is added to the diazo solution, and the hydrosulphite solution is then added fairly rapidly to the well-stirred diazo solution. Complete reduction takes place immediately, sulphur dioxide is evolved, and some of the hydrazine sulphonate is precipitated. 100 cc. of concentrated hydrochloric acid is added, and the solution boiled for a few minutes. A colourless solution of phenyl hydrazine hydrochloride is obtained, from which, on cooling to 0° C., the hydrochloride separates as a mass of white needle-shaped crystals. This is filtered off, pressed, and dried. Yield, 24·5 grms. (85 per cent of the theoretical).

A further quantity can be obtained from the mother liquor by adding a large quantity of concentrated hydrochloric acid. The mixture of the hydrazine hydrochloride and common salt which separates is removed by decantation and gives, on treating with caustic soda and extracting with ether, a further 1·5 grm. of the base (7 per cent theoretical). Alternatively the mother liquor may be rendered alkaline with strong caustic soda solution and extracted with ether, giving a further 5 per cent yield of the base. Hence a yield of over 90 per cent of the hydrazine is obtained by this method. The free base can be obtained from the hydrochloride in the ordinary way by shaking with 10-20 per cent caustic soda and extracting several

times with ether. The ethereal solution is dried with potash, filtered, freed from ether by distillation, and purified by distillation under reduced pressure.

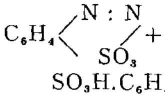
The hydrosulphite reduction process has certain advantages over the methods of reduction in use. Sodium bisulphite is not a sufficiently strong reducing agent to bring about the reduction to hydrazine sulphonate readily, hence Fischer used zinc and acetic acid as the reducing agent, but this cannot be used without first forming the diazo sulphonate. Hence a somewhat more energetic reducing agent than bisulphite, which moreover affects the reduction directly, is preferable, especially as there is no risk of further reduction occurring at the hydrazine group. As compared with V. Meyer's process, the hydrosulphite method has the advantage of giving pure phenyl hydrazine hydrochloride, whereas in the former method practical difficulties are introduced by the presence of tin The hydrosulphite process gives a better yield than either of the other methods.

The reactions are represented by the following equations—

$$C_6H_5N_2Cl+Na_2S_2O_4+H_2O = C_6H_5NH.NHSO_3Na+NaCl+SO_2.$$

$$C_6H_5NH.NHSO_3Na+HCl+H_2O = C_6H_5NH.NH_2.HCl+NaHSO_4.$$

Phenyl hydrazine p-sulphonic acid.—This can be readily prepared by a method similar to that used for preparing phenyl hydrazine, employing either one molecule or two molecules of hydrosulphite. In the latter case the hydrazine is obtained directly with a yield of about 53 per cent. Using one molecule of reducing agent the method is as follows: The solid diazo anhydride is first prepared by dissolving 19 grms. of recrystallised sulphanilic acid in 23 cc. of 20 per cent caustic soda and 100 cc. of water. Seven grms. of sodium nitrite are added, and the solution is poured into a cold solution of 12 cc. of strong sulphuric acid in 100 cc. water. The precipitated diazo compound is filtered off. The diazo compound in the form of a paste is reduced with a cooled solution of 22 grms. of hydrosulphite in 125 cc. of water, 20 cc. of hydrochloric acid being added during the reduction. The clear yellow solution of the *p*-sulphonic acid of phenyl hydrazine sulphonate of sodium which is thus produced, is easily hydrolysed by boiling with a further 30 cc. of hydrochloric acid. The free hydrazine is obtained directly as this hydrazine derivative forms no hydrochloride; 8·5 grms. of the pure base are obtained on crystallising, and the mother liquor gives a further 3 grms. on boiling down. This gives a total yield of 60 per cent of the theoretical, calculated on the original amine.

 $+Na_2S_2O_4+HCl+H_2O =$

$$SO_3H.C_6H_4NH.NHSO_3Na+NaCl+SO_2.$$

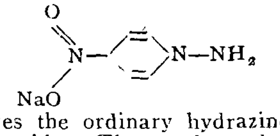
$$SO_3HC_6H_4N_2H_2SO_3Na+H_2O = SO_3H.C_6H_4NH.NH_2+NaHSO_4.$$

It is interesting to note that the theoretical quantity of reducing agent is employed, whereas in the ordinary method about 2½ times the theoretical quantity of bisulphite is generally used.

Para-nitro phenyl hydrazine.—The reduction of *p*-nitro benzene diazonium chloride with hydrosulphite does not give satisfactory results under the conditions given above, or, indeed, under any of our experimental conditions. This is due to several factors. *p*-Nitro phenyl hydrazine differs from the hydrazines already dealt with in being further reducible both at the hydrazine group and the nitro group the ultimate reduction product being *p*-phenylene diamine. Consequently, the sulphonic groups cannot be removed from the hydrazine disulphonate by the further action of hydrosulphite. Moreover, it is not theoretically possible to prepare the hydrazine disulphonate by the action of hydrosulphite alone, whether the latter goes to sulphite or sulphate, and there is no monosulphonate. Furthermore, the product of the reduction always resinifies, thus accounting for the presence of unreduced diazo sulphonate. The best yield of hydrazine was obtained under the following conditions: 42 grms. of *p*-nitraniline were boiled with 200 cc. of water and 100 cc. of concentrated hydrochloric acid, and the solution cooled in a freezing mixture. This was diazotised at a low temperature by rapidly adding 24 grms. of sodium nitrate dissolved in 50 cc. of water. The filtered diazo solution was treated with 30 cc. of concentrated hydrochloric acid, stirred mechanically, and slowly reduced at a temperature not exceeding 2° C. with 130 grms. of hydrosulphite dissolved in 700 cc. of water. The solid product contained both the hydrazine hydrochloride and hydrazine disulphonate, and gave 13 grms. of the hydrazine base after hydrolysing and treating with sodium carbonate and sodium acetate. The mother liquor gave 6 grms. of the base on neutralising, and after salting out the remaining hydrazine disulphonate, this gave a further 4 grms. of the base. By extracting with ether a further small quantity was obtained. This makes a total yield of 24 grms. or 53 per cent of the theoretical.

When the reduction is carried out in sodium carbonate solution, the main product appears to be *p*-nitro diazo benzene imide.

Para-nitro phenyl hydrazine can, however, be prepared by reduction of sodium *p*-nitro isodiazo benzene with hydrosulphite in alkaline solution, the method being similar to that used for the estimation of this diazo or nitrosamine compound. The product is a tautomeric form of *p*-nitro phenyl hydrazine which is supposed to have a quinonoid structure and forms a sodium salt, as shown by Baly and Tuck (*J. Chem. Soc.*, 1906).



This gives the ordinary hydrazine on neutralising with acid. The product obtained in this preparation consists of a mixture of *p*-nitro phenyl hydrazine with a small proportion of the hydrazine disulphonate. It is best to isolate the nitrosamine compound and to carry out the reduction fairly rapidly so as to minimise the proportion of hydrazine disulphonate formed. Under certain conditions the product is obtained on neutralising in a finely divided form which is difficult to isolate. This is obviated if the acid hydrolysis is carried out as described below without isolating the hydrazine. The production of hydrazine compound was shown by titrating the solution resulting from this preparation to be practically quantitative.

The nitrosamine compound is obtained by pouring the diazo solution into caustic soda, as described by Schraube and Schmidt (*Ber.*, 27, 514).

Ten grms. of the pure nitrosamine compound, $NO_2C_6H_4N_2ONa,2H_2O$, was mixed with a little water containing 6 grms. of caustic soda and reduced at 0° C. with 20 grms. of hydrosulphite dissolved in 120 cc. of water. Some of the hydrazine base crystallised out as the quantity of alkali was only slightly in excess of that required by the equation :

$$NO_2C_6H_4N_2ONa+2Na_2S_2O_4+3NaOH = NO_2C_6H_4N_2H_3+4Na_2SO_3.$$

200 cc. of hydrochloric acid was added and the solution boiled, in order to hydrolyse the small quantity of hydrazine sulphonate present. On neutralising the cooled solution with sodium carbonate and sodium acetate, 6·2 grms. of *p*-nitro phenyl hydrazine was obtained. Ether extraction of the mother liquor gave a further 0·3 grm. of the base. The total yield is 95 per cent of the theoretical.

Meta-nitro phenyl hydrazine.—The action of hydrosulphite on *m*-nitro benzene diazonium chloride under various conditions was investigated with the object of preparing *m*-nitro phenyl hydrazine. The reduction is analogous to that of the *p*-nitro compound, but only comparatively low yields of the hydrazine (40 per cent) were obtained, together with the hydrazine disulphonate, the diazo sulphonate, and, when working in sodium carbonate solution, the diazo imide.

Use of titanous salts for the reduction of diazo compound.—It has been stated in a previous paper that phenyl hydrazine is not obtained by the action of titanous salt on benzene diazonium chloride, the product being diazo benzene phenyl hydrazide, which is a condensation product of the diazo compound with phenyl hydrazine. In the case of diazotised *p*-nitraniline a similar reaction probably occurs, as only about half the theoretical quantity of reducing agent is used up. By carrying out the reduction with this reduced quantity of titanous sulphate, a bulky red precipitate was obtained which was extracted with alcohol and treated with sodium carbonate. The product thus obtained was free from titanium and contained no diazo imide. It was insoluble in cold water, decomposed by hot water, and melted at 65-70° C. By treating with alcoholic potash or alkaline hydrosulphite and then acidifying, *p*-nitro phenyl hydrazine was formed. Hence the substance was probably a diazo hydrazide, and although the compound $NO_2C_6H_4N : N.N(NH_2)C_6H_4NO_2$ has not been previously described, Bamberger (*Ber.*, xxviii., 840) obtained a very similar compound of the formula $NO_2C_6H_4N : N.N.(NH_2)C_6H_4$.

It has now been found that analogous reactions take place when stannous chloride and bisulphite of soda are used as reducing agents, the equivalent of only one molecule (=2H instead of 4H) of either of these being sufficient to prevent the coupling of a solution of diazotised *p*-nitraniline with β-naphthol. These results have some bearing on the method of producing white resists under insoluble azo colours in calico printing. In the printing of stannous chloride and bisulphite resists on β-naphthol prepared cloth under diazotised *p*-nitraniline or α-naphthylamine, it is generally assumed that the diazo compounds do not touch the printed parts owing to their being instantly reduced to hydrazine compounds. This evidently does not take place, and the fact that no colour develops is due to other causes. Presumably in the case of diazotised *p*-nitraniline, a precipitate of the insoluble diazo hydrazide is immediately formed where the diazo compound comes in contact with the stannous chloride. Furthermore, the stannous chloride used is capable of destroying, as far as the coupling effect is concerned, twice as much of the diazo compound as if it brought about the reduction to the ordinary hydrazine.

In the case of diazotised meta-nitraniline, a similar reaction apparently occurs, but here the diazo hydrazide is further reducible either by titanous or stannous salts, and it has therefore been possible to prepare *m*-nitro phenyl hydrazine by using titanous sulphate as reducing agent. The product of the reduction is a yellowish-orange frothy precipitate, which is remarkably bulky. After filtering and extracting with hot alcohol, the alcoholic solution gives a flocculent precipitate of what appears to be the titanium double salt of *m*-nitro phenyl hydrazine. Such double salts of titanium with a salt of an organic base are very rare, and an attempt was made to purify some of this as the oxalate, but it could not be obtained crystalline. The free hydrazine base was obtained from the solution of the double salt by treating with sodium acetate, boiling, and filtering from the residue of titanic hydrate. The yield of the base thus obtained is 65 per cent of the theoretical. This method of preparation does not seem to be of much value, owing to the practical difficulties which are encountered.

Thus it is evident that sodium hydrosulphite can be used with advantage in the preparation of hydrazine derivatives, in place of bisulphites and stannous salts, which have formerly been almost invariably used. In certain cases titanous salts may be used for the purpose, but do not offer any advantages. In conclusion, I wish to thank Prof. Knecht for his direction and supervision of this work.

THE CHEMISTRY AND CRYSTALLOGRAPHY OF SOME FLUORIDES OF COBALT, NICKEL, MANGANESE AND COPPER.*

By FLOYD H. EDMINSTER and HERMON C. COOPER.

(Continued from p. 30.)

Cobalt Fluoride Analysis.—The fluorine of the cobalt fluoride was determined by adding an excess of standard alkali to the water solution. The precipitate was four times washed by decantation with hot water, whereupon it was brought upon the filter and washed with hot water until the washings gave no test for alkali with phenolpthalein. The filtrate was then titrated with standard hydrochloric acid and the weight of sodium hydroxide used was calculated. In order to check this method, determinations were made by precipitating the fluorine with calcium acetate. The results were lower than by titration, and are not considered reliable.

*A more detailed account of this work was submitted to the Faculty of the Graduate School of Syracuse University by Floyd H. Edminster in May, 1918, in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

All of the general methods were used for determining cobalt metal. The first method employed was that of precipitating with sodium hydroxide, filtering the precipitate, and washing it with hot water. The dried hydroxide was ignited and the oxide decomposed with concentrated sulphuric acid. This acid solution was then evaporated to dryness and the anhydrous cobalt sulphate weighed.

Another method used for cobalt was to treat the fluoride with sulphuric acid and evaporate. This should volatilise all of the constituents except the metal. Consistent results were obtained by this method which agree with the electrolytic determinations. The reaction with sulphuric acid is vigourous and complete within a few minutes. The sulphuric acid is then driven off in an air-bath, the residue heated for five minutes and eventually weighed as anhydrous cobalt sulphate.

In electrolytic deposition, cobalt does not behave ideally; it does not always form a good coating on the cathode, but often scales off before the deposition is complete. We carried out the electrolysis as specified by Treadwell-Hall (Treadwell-Hall, "Analytical Chemistry" II., 1915, p. 138, 4th ed., N.Y.). Our experience has been that, if the voltage exceeds 1·5 volts, the cobalt will precipitate as the hydroxide, and, if the solution is not kept strongly alkaline, a black ring will be deposited, particularly around the edge. A voltage of 1·0 to 1·5 and an amperage of 1·0 to 1·3 gave the best results. A 100-cc. platinum basin served as the cathode. It is not necessary to precipitate the hydroxide of cobalt, but the crystals may be dissolved in water, ammonium hydroxide added, and the solution electrolysed directly. The possibility of contamination with alkali is eliminated and accurate results are to be expected, but no determination of fluorine can be made on the same sample.

Cobalt hydroxide was also reduced to the metal by the Rose method. Unfortunately, the ignited precipitate was always in masses, which would not reduce unless removed from the crucible and ground. If this was not done, the reduction was incomplete, and the results were too high.

Nickel Fluoride Analysis.—In the nickel fluoride the fluorine was determined as in the case of cobalt. The metal also was determined (1) as the anhydrous sulphate, after evaporating the fluoride crystals with sulphuric acid; (2) by electrolysis; and (3) as the oxide. Unlike cobalt oxide, nickel oxide has a constant composition and the metal can be calculated from the weight of the oxide.

Anhydrous nickel sulphate is hygroscopic and must be weighed quickly after removal from the desiccator. The electrolysis was conducted in a strongly alkaline solution with a voltage of about 1·5 and an amperage of 1·5. In all cases the platinum basin was used as the cathode.

No analyses for nickel were made by the Rose method.

Copper Fluoride Analysis.—The copper is best determined (1) by electrolysis in the water solution of the crystals, which are acid with hydrofluoric acid, unless the fluorine is to be determined in the same sample. In the latter case, the copper is precipitated as the hydroxide, dissolved in dilute nitric acid, and subjected to electrolysis. Copper was also determined (2) by evaporating the crystals with sulphuric acid. (3) When the copper fluoride crystals are heated alone, they give off water and hydrofluoric acid and are converted to the oxide. The weight of copper calculated from the oxide thus obtained agrees approximately with that obtained by other methods.

Manganese Fluoride Analysis.—The fluorine was determined by the same method as for the other fluorides. The metal was determined (1) by decomposing with sulphuric acid, and (2) by converting to the pyrophosphate. For the latter method the manganese is first precipitated as the hydroxide, washed free from alkali and dissolved in dilute sulphuric acid.

The Analytical Data.—The results of the analyses are tabulated in the following tables. The numbers in the first column are analytical reference numbers; the method employed in the analysis is indicated in the second column; the weights of salt and constituent, respectively, are given in the next two columns; the computed percentage is found in the fifth column; while below will be found memoranda that might aid in the appraisal of the results.

Cobalt Fluoride.

Prepared by the action of HF on the hydroxide or carbonate, no difference being seen in the products.

Reference No.		Salt. G.	Fluorine. G.	Per cent.
6	Pptd. as CaF_2 ...	0·3000	0·1214	39·97
3	Titration	0·5000	0·1310	41·30
63	Titration	0·3000	0·1221	40·78
64	Titration	0·4007	0·1695	41·45
90	Titration	0·3000	0·1285	42·85(a)
130	Pptd. as CaF_2 + CaC_2O_4	0·2934	0·1458	42·79(a)
131	Pptd. as CaF_2 + CaC_2O_4	0·2280	0·1232	43·79(a)

(a) Taken from solution, washed, dried, and analysed immediately.

Reference No.		Salt. G.	Metal. G.	Per cent.
37	Dissolved hydroxide in H_2SO_4 and electrolysed ...	0·3026	0·0591	19·53(a)
39	Dissolved hydroxide in H_2SO_4 and electrolysed ...	0·4483	0·0864	19·27
50	Decomposed with H_2SO_4 and weighed as $CoSO_4$ ...	0·3520	0·1793	19·36
63	Electrolysis ...	0·3000	0·0571	19·40
78	Electrolysis ...	4·4007	0·7840	19·40(b)
93	Electrolysis ...	0·3000	0·0590	19·60(c)
51	Electrolysis ...	0·2544	0·0484	19·03(d)

(a) Crystals were washed in alcohol.
(b) Very clean crystals.
(c) Dissolved in water and electrolysed.
(d) Dehydrated.

Reference No.		Salt. G.	Metal. G.	Per cent.
51	Heating and collecting the water	0·2544	0·1036	40·70
130	Heating and collecting the water	0·3024	0·1195	39·52
133	Heating with PbO	0·3313	0·1363	41·14
135	Heating with PbO	0·1853	0·7440	41·15
137	Heating and collecting the water	0·2107	0·8650	41·05

Nickel Fluoride.

Prepared from the hydroxide and hydrofluoric acid.

Reference No.		Salt. G.	Fluorine. G.	Per cent.
58	Titration	0·3000	0·1259	41·99(a)
80	Titration	0·3000	0·1658	41·36(b)
89	Titration	0·3000	0·1296	43·27(c)
96	Titration	0·3000	0·1292	43·05(d)
97	Titration	0·3000	0·1248	41·67(e)
131	Pptd. as CaF_2+ CaC_2O_4	0·1876	0·0914	43·76 (f)

(a) Washed in alcohol.
(b) Old crystals.
(c) Clean crystals fresh from solution.
(d) Clean crystals fresh from solution.
(e) Old crystals
(f) Crystals fresh from solution.

Reference No.		Salt. G.	Metal. G.	Per cent.
54	Electrolysis ...	0·3070	0·0677	19·80
58	Electrolysis ...	0·3000	0·0584	19·60
62	Electrolysis ...	0·3000	0·0574	19·50
64	Electrolysis ...	0·2497	0·0489	19·58
91	Electrolysis ...	0·3000	0·0478	19·26

Reference No.		Salt. G.	Water. G.	Per cent.
110	Heating and collecting water in H_2SO_4	0·2764	0·1149	41·50

Manganese Fluoride.

Reference No.		Salt. G.	Fluorine. G.	Per cent.
76	Titration	0·3537	0·1313	43·02(a)
69	Titration	0·3004	0·1190	39·63
92	Titration	0·3020	0·1220	40·68

(a) Crystals fresh from solution.

Reference No.		Salt. G.	Metal. G.	Per cent.
76	Heating with H_2SO_4 and weighing as $MnSo_4$	0·0365	0·1817	18·09
60	Heating with H_2SO_4 and weighing as $MnSO_4$	0·3537	0·1810	18·89
77	Heating with H_2SO_4 and weighing as $MnSO_4$	0·2892	0·1457	18·35

Reference No.		Salt. G	Water. G.	Per cent.
127	Heating with PbO and collecting the water	0·3171	0·1221	38·2

Copper Fluoride (Crystals).

Reference No.		Salt. G.	Fluorine. G.	Per cent.
43	Titration	0·3000	0·1282	42·76
59	Titration	0·3000	0·1281	42·71
65	Titration	0·4220	0·1808	43·05
127	Precipitation ...	0·3612	0·1519*	42·20

* CaF_2+CaC_2O_4

Reference No.		Salt. G.	Metal. G.	Per cent.
59	Electrolysis ...	0·3000	0·0610	20·30
60	Electrolysis ...	0·3000	0·0602	20·07
61	Electrolysis ...	0·3009	0·0604	20·06
79	Electrolysis ...	0·4112	0·0838	20·38

Copper Fluoride (Crystalline Crust).

Reference No.		Salt G.	Fluorine. G.	Per cent.
52	Titration	0·6087	0·1692	27·80(a)
53	Titration	0·6896	0·1270	27·00
56	Titration	0·5000	0·1437	28·75
74	Titration	1·1751	0·3323	28·28
83	Titration	0·9401	0·2646	28·13

(a) These two are the same preparation.

Reference No.		Salt. G.	Metal. G.	Per cent.
52	Electrolysis ...	0·0609	0·2814	46·10
53	Electrolysis ...	0·6896	0·3158	45·80
82	Electrolysis ...	0·8219	0·3767	45·83
83	Electrolysis ...	0·9401	0·4306	45·82
49	Electrolysis ...	0·3621	0·1643	45·40

(To be continued.)

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, January 20, 1921.

PROF. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read :—

"The Magnetic Mechanical Analysis of Manganese Steel." By Sir ROBERT HADFIELD, S. R. WILLIAMS, and I. S. BOWEN.

This paper is an attempt to correlate some of the magnetic and mechanical properties of manganese steel. Tests were made on six rods quenched in water, when they are in the non-magnetic condition, and three were afterwards annealed, which renders them magnetic. The changes in length of the rods when subjected to magnetic fields were determined (Joule Effect). In the case of the rods in the magnetic condition the change was an increment for all field strengths. No change in length to 0·000004 cm. could be detected for the non-magnetic specimens.

The effect on the intensity of magnetisation when subjected to longitudinal stress was investigated (Villari Effect). An absolute method of measuring the intensity of magnetisation when comparatively small was adopted, consisting in the use of an exploring coil made up of two coils in series so arranged that the E.M.F. generated in the first balances that in the second, and calibrated by means of a long solenoid of general dimensions equal to those of the rods tested. For all field strengths the application of tensile stress increased the intensity of magnetisation of the magnetic specimens.

The non-magnetic rods showed no change in intensity of magnetisation by being stretched. They did, however, show an intensity of magnetisation about 1/36 of that of the specimens in the magnetic condition. This effect was found to be entirely due to oxidation of the skin of the rods, for, on removing a few thousandths, the specimens showed no magnetic susceptibility when tested by a hand magnet.

"A Selective Hot-wire Microphone." By W. S. TUCKER, D.Sc., and E. T. PARIS.

The instrument consists of an electrically heated grid of fine platinum wire placed in the neck of a Helmholtz resonator. The effect of a sound

having the same frequency as that natural to the resonator itself is to produce an oscillatory motion of the air in the neck of the resonator, which in turn causes changes in resistance of the platinum wire grid. The total resistance change comprises a steady fall in resistance, due to an average cooling of the grid and a periodic change due to the to-and-fro motion of the air.

Two methods of using the microphone are described :—

(i.) A Bridge method, depending on the steady drop in resistance, and

(ii.) An Amplifier method which makes use of the periodic resistance changes.

Curves are given showing the sharpness of resonance a smeasured by the Bridge method. The various factors affecting the sensitivity of the microphone are discussed.

Results of experiments on cooling the grid bv low-velocity air-currents are described. It is deduced that the principal resistance changes to be expected when the grid is cooled by an oscillatory air-current are :—

(1) A steady drop due to an average cooling;

(2) A periodic resistance change of the same frequency as that of the sound; and

(3) A periodic resistance change of frequency twice that of the sound.

All these effects are found in practice. Further deductions are that the steady change of resistance is proportional to the *intensity* of the sound, while the periodic resistance change in (2) is proportional to the *amplitude*. These conclusions are confirmed by experiment.

"*Siren Harmonics and a Pure-tone Siren.*" By E. A. MILNE and R. H. FOWLER.

The ordinary siren can be regarded as a point source of air variable flux, the flux being proportional to the area of the orifice exposed by the holes in the disc. In general the tone from such a siren is far from pure.

The relative intensities of the harmonics for a siren with circular holes and a circular orifice are calculated and compared with experiment. It is concluded that a fairly pure note should be obtained from a siren of this type, in which the distance between the centres of adjacent holes is twice the diameter of the holes.

If, however, the original is rectangular in section, the holes can be so shaped that the area of the orifice exposed varies exactly as the sine of the displacement. Such a siren should produce a very pure tone.

Experimental tests of a siren constructed on these lines are quoted and discussed.

"*Design of Diaphragms capable of Continuous Tuning.*" By L. V. KING.

In designing submarine sound generators and receivers it is important to be able to tune the diaphragm to a desired pitch, thus realising selective transmission and reception.

A type of diaphragm so constructed that continuous tuning is achieved by the application of air-pressure (or suction) was designed by the writer and is designed in detail. It is constructed from a single piece of metal, and consists of a thick, undeformable, central disc, connected by a thin, concentric, annular portion, to a heavy circular rim, which is fited very accurately on a rigid mounting. The application of air-pressure over the interior of the diaphragm alters the tension of the thin annular portion, so that the rigid central portion vibrates about the static equilibrium position with a different pitch.

A steel diaphragm, 3in. in diameter, was constructed in the manner described. A range of pressure from —25cm. of mercury to +25 cm. altered the pitch of the diaphragm vibrating in air from 430 to 620, and vibrating in water from 370 to 530.

By comparing the frequencies corresponding to the same pressures on the diaphragm when vibrating in air and water, it is shown that the *accoustic mass* amounted to as much as 40 per cent of the actual mass.

To realise sharp tuning and high sensitivity, it was concluded as a result of experience that diaphragms of this type should be made with almost optical precision in the form of accurate solids of revolution.

CORRESPONDENCE.

GLUCOSAZONE SULPHURIC ACIDS.

To the Editor of the Chemical News.

SIR,—While the glucosazones are well-known compounds, their sulphuric acids do not seem to have been prepared and described.

A short investigation of these bodies was undertaken early in 1920, with the following results.

(1) Sodium phenylglucosazone para sulphurate was prepared by heating phenylhydrazine para sulphuric acid with glucose and sodium acetate in aqueous solution: it was obtained as a pale lemon yellow powder, very soluble in water, slightly soluble in absolute alcohol, and insoluble in ether, acetone, benzene, &c. I have not succeeded in crystallising it.

(2) Sodium phenyllactosazone para sulphonate was prepared in the same way, and has similar properties.

(3) Sodium naphthylglucosazone 1 : 4 sulphonate was obtained in a similar way from naphthylhydrazine 1 : 4 sulphuric acid (prepared from naphthianic acid): it is a powder similar to the above, though not such a pure colour.

These osazones are dyes similar to phenyl glucosazone para carboxylic acid described by Kodak, Ltd., in the *British Journal of Photography* in 1919.

It is clear that by the use of halogen and other derivatives of phenyl and naphthylhydrazine sulphuric acids many new osazones could be prepared; also various sugars and substances such as glycerine aldehyde which contain the group —CHOH—CHO might be employed.

Since one molecule of a sugar combines with two of a hydrazine derivative to form an osazone, it seems to me probable that two further series of compounds could be prepared; (*a*) where one molecule of a sugar combines with one molecule of a dihydrazine derivative obtained from diamines such as phenylene and toluylene diamines;

(*b*) where one molecule of a sugar combines with *one* molecule of a dihydrazine derivative obtained from benzidene, tolidine, &c.

I think that some of these new osazones would be likely to prove of considerable interest, and possibly also of value as dyes. Lack of time has so far prevented my preparing more than the three compounds above mentioned.—I am, &c.,

A. F. Kitching (M.A Oxon.).

Monkton Combe School,
Near Bath.

NOTES.

Anhydrous Sulphates and the Theory of the Magneton.—When a substance in the form of gas or solution obeys the law of Curie, a single measurement at the ordinary temperature enables determination of the atomic moment. Such is not so when the paramagnetic salts are solid. Study of the thermic variation then becomes essential to determine by means of the Curie point, the constant of the molecular field. The experiments of M. Théodoridès dealt with the three manganous cobaltous and ferric sulphates in the anhydrous form and the method employed was that of the attraction in a non-uniform field with electrodynamic compensation of the magnetic force exerted. For each of the three substances studied, the inverse of the specific coefficient of magnetisation, in function of the temperature, is given by two parallel lines, with a slight intervening deviation, and united by a faint curvilinear region; the ensembling the phenomenon is exactly reversible. Finally the error in calculation of the molecular constant did not attain 6 per 1000; it is reduced to half this figure when estimating the number of magnetons.—*Comptes Rendus*, November 15, 1920.

Purification of Sewage by the "Activated Sludge" Process.—We are aware that in aërating sewage sludge by blowing air through it, this sludge will after a certain time acquire the faculty of purifying the sewage with which it is in contact. Aëration being sufficiently maintained, purification is obtained in a few hours, provided that the proportion of the mixture is suitable. As soon as activity appears there is a sudden fall of ammonia which is found in form of nitrous and nitric acid. M. Cavel describes his experiments in this note and maintains that this transformation of ammonia is a microbial phenomenon. Experiments were made in an alkaline medium which is the normal reaction of sewage. If we change the reaction by slightly acidulating, the action is no longer the same, there is no change in the ammonia; percentage remains constant which is in harmony with what is known regarding the sensitiveness of nitrobacters with regard to acidity of the medium—*Comptes Rendus*, January 8, 1921.

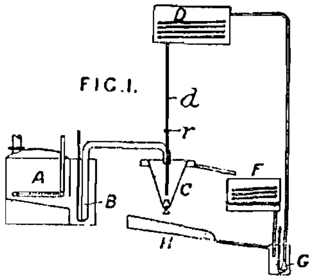
New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Abstract Published this Week.

Mr. R. Lessing of High Holborn, London, has obtained a Patent for apparatus for treating Ammonium Sulphate No. 152766 The colouring matter usually associated with crystals of ammonium sulphate is removed by agitating the latter, in a detached condition in a clear saturated solution of that salt maintained slightly acid—if necessary by the addition of sulphuric acid—and floating of the suspended impurities. The agitation may be performed mechanically, or by blowing with air or steam, but preferably it is effected by means of the saturated ammonium sulphate solution, which enters at a point near the bottom of the conical-shaped treatment vessel containing the crystals. The rapid stream on entering stirs up the crystals but as the diameter of the vessel increases only the impurities remain suspended. Fig. 1 indicates a saturator A from which crystals are removed to the vessel C by means of steam lift B. A stream of filtered saturated ammonium sulphate enters by pipe d, and is regulated by valve r. The temperature of the liquor throughout the system is maintained at the same temperature as the crystals coming from the saturator, by means of steam coils in the storage tank D and the filter F. The clean crystals are discharged periodically on to the drainer H, the liquor collecting in the sump G from which it is raised to tank D by means of an air lift. An ordinary saturator may also be adapted for the process. Crystals having been deposited, the passage of ammonia is reduced or stopped. A filtered saturated solution of sulphate of ammonium is supplied near the bottom of the saturator and overflows through a launder and passes to the filter as previously described.

FIG. 1.



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MEETINGS FOR THE WEEK.

Monday, January 31, 1921.

Royal Society of Arts, 8.

Tuesday, February 1.

Royal Institution, 3. "The British Soldier since the Restoration—In Peace," by Hon. J. W. Fortescue.
Royal Society of Arts, 4.30.
Röntgen Society, 8.15.

Wednesday, February 2.

Royal Society of Arts, 4.30.
Society of Public Analysts, 8. (Annual Meeting). "Extract of Red Squill as a Rat Poison," by F. W. Smith. "Composition of Harrogate Mineral Waters," by W. Lowson.

Thursday, February 3.

Royal Society, 4.30. "The field of an electron on Einstein's Theory of Gravitation," by G. B. Jeffery. "A Physical Theory of Stellar Spectra, by M. N. Saha "The ultra-microscopic Structnre of Soaps," by W. F. Darke, J. W. McBain, and C. S. Salmon. "Linear Transformations and Functions of positive Type," by J. Mercer.
Royal Institution, 3. "Oceanography—Great Exploring Expeditions," by Prof. W. A. Herdman.
Society of Chemical Industry, 7.30. (At Bristol).
Chemical Society, 8.

Friday, February 4.

Royal Institution, 9. "Electrical Expression of Human Emotion," by Augustus D. Waller.
Society of Chemical Industry, 7. (Manchester and Cardiff).

Saturday, February 5.

Royal Institution, 3. "The Madrigal—Technique," by Percy C. Buck.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

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THE CHEMICAL NEWS.

VOL. CXXII., No. 3173.

ON DENTAL INCRUSTATIONS AND THE SO-CALLED "GOLD-PLATING" OF SHEEP'S TEETH.

By THOS. STEEL.

FOR many years past there have appeared from time to time, in newspapers and magazines published all over the world, statements as to the occurrence of a metallic incrustation on the teeth of sheep. The incrustation in question is usually found more or less thickly coating the sides of the molar teeth, and, being frequently of a shining, yellowish, metallic appearance, has been popularly attributed to gold supposed to have been derived from particles of that metal scattered about the pastures. So deeply-rooted is the popular belief that the incrustation consists of gold, my friend, Mr. J. H. Campbell, informs me that persons have brought jaws of sheep to the Royal Mint, Sydney, with a view to selling them for the supposed adherent gold. Quite recently, it was most confidently asserted by correspondents in *Nature*, 1917, xcix., 264, 284, 290, 304; 1917, c., p. 106, that the incrustation consisted of iron pyrites, and various fantastic theories were put forward to account for the presence of this substance in such a situation.

In 1905, Prof. Liversidge exhibited at a meeting of the Royal Society of New South Wales part of a sheep's jaw, heavily coated with yellow metallic looking deposit, and read a descriptive note with a qualitative analysis, clearly showing the true nature of the substance to be a deposit derived from the saliva, and that the metallic appearance was due to the refraction of light by the overlapping edges of the thin lamellae of the deposit (*Journ. Roy. Soc., N.S. Wales*, 1905, xxxix., 33; also CHEMICAL NEWS, 1905, xcii., 115; *Journ. Soc. Chem. Ind.*, 1905, xxiv., 1039. Again, in July, 1905, the same gentleman exhibited and explained the deposit at a meeting of the Sydney section of the Society of Chemical Industry. Similar specimens were exhibited by Horan to the New South Wales Naturalists' Club in 1913 (*Australian Naturalist*, 1913, ii., 174, 187).

As will be shown in this paper, the presence of such deposits is by no means confined to the teeth of sheep, but is a common occurrence on those of a very large variety of animals, including man. It is, in fact, a dental calculus analogous to those occurring in the urinary tract.

The earliest account of the true nature of dental incrustations with which I have met, occurs in the *Annals of Philosophy* (Thomson's *Ann. Phil.*, 1814, ii., 380). In the course of a series of articles entitled "General Views of the Composition of Animal Fluids," Berzelius gives a correct explanation of the nature of the deposit from human teeth, and his analysis of a specimen, which will be quoted further on.

In 1834, Dr. G. Bennett ("Wanderings in New South Wales," 1834, i., 294) records having observed a layer of "metallic substance" incrusting the teeth of kangaroos, and correctly diagnosed it as "tartar" precipitated from the saliva. He mentions its occurrence in the ox and sheep, and remarks that on account of its yellow colour it is frequently mistaken for gold. He quotes the analysis by Berzelius mentioned above.

In a paper published in 1879, "On Macrodontism," N. de Miklouho-Maclay (*Proc. Linn. Soc. N.S. Wales*, 1879, iii., 169) described and figured the huge projecting teeth which he observed in natives of the Taui or Admiralty Islands, and refers to a sketch in *Nature*, 1877, xvi., 251, which he describes, however, as a caricature. In a subsequent paper (*Proc. Linn. Soc. N.S. Wales*, 1886, x., 682) he explains that further investigation had shown that he was mistaken in supposing that the projections were due to dental malformation, but that they really consisted of an enormous deposit of "tartar," probably largely due to the habit of these people of chewing betel nut and lime. The deposit could be detached, leaving the teeth quite normal. The late Mr. R. P. Pedley, surgeon-dentist, who examined the deposit, identified it as dental tartar. Unfortunately there is no record of a chemical examination having been made. Miklouho-Maclay proposed the term "odontolithiasis" for this condition.

From the stocks of bones passing through a large bone charcoal factory in Sydney, I have been able to examine the teeth of numerous sheep, and also those of oxen, horses, pigs, etc., and to secure ample material for a complete chemical analysis of the deposit from the teeth of sheep and oxen. From other sources I have obtained sufficient for quantitative analysis from the teeth of a number of animals, including man. By the courtesy of the late Mr. R. Etheridge, specimens from the teeth of animals in the Australian Museum, Sydney, were secured, sufficient in a few cases for full analysis, and in a considerable number of others for qualitative determination. Mr. H. A. Longman, F.L.S., Director of the Queensland Museum, kindly allowed me material from the skeleton of a camel. In all such cases care was taken to insure that the deposit obtained was pure and not contaminated with lime which may have been used in the preparation of skeletons.

Very commonly the taxidermists appear to have carefully cleaned the teeth. My kinsman, Mr. A. Ross Brown, B.D.Sc., L.D.S., of Windsor, Melbourne, and my friend, Mr. J. Darton, surgeon-dentist, Petersham, furnished me with an ample supply from human teeth, secured in the course of their professional practice in the operation of "scaling." Mr. Charles Hedley, Acting Curator of the Australian Museum, kindly gave me facilities, with the aid of Messrs. Thorpe and Troughton, to examine the large collection of skulls in the Museum. To Prof. J. Douglas Stewart, of the Veterinary School, Sydney University, I am indebted for explaining to me details regarding the structure of teeth and giving me other information. To all of these gentlemen I desire to tender my best thanks. Further material was obtained from specimens in my own collection and passing through my hands. In addition to examining the dental deposit, I have, in the cases of the ox and camel, made an analysis of the cement or cementum layer (*crusta petrosa*). In these animals this layer is strongly developed, extending well up on the exposed part of the tooth, and

Analyses of Dental Incrustations.

	Man	Sheep	Ox	Camel	Dromedary	Rhinoceros	Babirussa	Cement layer (*Crusta petrosa*) Ox	Cement layer (*Crusta petrosa*) Camel
Lime (CaO)	40·75	28·00	29·38	37·75	37·00	46·13	47·50	35·69	36·21
Magnesia (MgO)	0·18	4·19	3·69	0·27	0·18	0·56	0·68	1·12	0·98
Phosphoric oxide (P_2O_5) ...	34·73	26·55	28·17	29·33	29·48	7·95	7·14	26·68	26·88
Carbon dioxide (CO_2) ...	1·32	1·45	1·10	2·70	2·88	22·65	41·63	2·90	1·80
Organic matter*	17·23	24·65	23·90	16·20	16·82	17·48	41·63	23·54	24·74
Water at 110° C.	5·38	11·03	10·30	11·65	10·40	3·85	2·63	9·35	8·66
Sand	0·10	2·30	2·00	0·60	0·30	0·55	0·39	nil	nil
Undetermined and loss ...	0·31	1·83	1·46	1·50	2·94	0·83	0·03	0·72	0·73
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
*Containing nitrogen ...	1·20	1·48				0·74			
Sp. Gr.	2·317	2·025						2·112	

can be readily separated. The incrustation could, in most cases, be easily flaked off from either the cement or the enamel and the surface beneath was always quite sound.

The figures following give the results. The samples were ground, and air-dried at ordinary temperature.

Miklouho-Maclay mentions that specimens of teeth similarly encrusted to those which he describes were forwarded by F. A. de Roepstorff from the Nicobar Islands to Professor Virchow, Berlin (*Verh. Berlin. Ges. Anthrop.*, June, 1881, p. 219). The deposit from these was analysed by Salkowski, and the results published by Virchow, the following being the figures:—

Water	5·95
Organic matter	9·10
Silica and iron oxide	0·87
Iron phosphate	2·26
Lime	45·24
Magnesia	0·68
Phosphoric oxide	30·73
Carbon dioxide	4·87
	99·70

This shows more lime and carbon dioxide and considerably less organic matter than I found in the normal incrustation from human teeth. Probably this is a result of the addition of carbonate of lime from the lime-betelnut habit, but the high phosphoric acid shows that essentially the deposit has been derived from the saliva. The presence of so much iron phosphate is peculiar, and I am unable to explain it. I found no appreciable iron in any of my samples.

The analysis by Berzelius mentioned above, is thus stated:—

Earthy phosphates	79·0
Mucus	12·5
Peculiar salivary matter	1·0
Animal matter soluble in muriatic acid	7·5
	100

There is no mention of water. It is probable that Berzelius merely ignited and took the ash as "earthy phosphates," and the organic substances include water. For a rough comparison it will suffice to consider the "phosphates as being tribasic phosphate of lime and to lump together the organic substances. This would give:—

Lime	43·0
Phosphoric oxide	36·0
Organic matter and water ...	21·0
	100·0

These figures agree very well with my analysis of the human product. In my examination I found the total loss on ignition, including water and carbon dioxide, was 24 per cent, and the ash 76 per cent.

In my analysis, in every case the sand was in the form of mechanically embedded grains. It will be noticed that the incrustations from the Rhinoceros and Babirussa (a pig-like animal from N. Celebes) differ from the others in containing but little phosphoric acid and a considerable proportion of calcic carbonate. In both of these the scale, when detached, was in appearance much like that from the sheep and ox, being in clean shining flakes. In man it is chalky-looking and has not got the metallic, or more commonly, nacreous look of that from the sheep. The similarity in composition between most of the incrustations and that of the cement layers of ox and camel is striking. Ordinary mammalian bone has also a very similar composition ("Watt's Dict. Chem.," 1879, vi., 1st Supp., 357).

In making the analyses, care was taken in separating lime and magnesia, by double precipitation of the lime in the cold to avoid co-precipitation of magnesia. The proportions of lime and phosphoric acid present are such as to indicate that the phosphate of lime does not exist entirely as the tribasic ($Ca_3P_2O_8$), but that a variable amount of the tribasic ($Ca_4P_2O_9$) is also present. I have found this to be a usual condition in many natural phosphates such as those from Ocean Island.

Bearing in mind the analogy between these dental salivary incrustations and urinary calculi, a careful examination was made of those from man, sheep, and ox, for oxalic and uric acids, but with entirely negative results.

I have examined the deposit from a large variety of animals in addition to those already mentioned, using micro-chemical methods when the amount available was minute, and in every case have found it to be of substantially the same nature. The quantity present varies from a mere trace of brown film, to a heavy incrustation packed round the crowns of the teeth and forming a continuous coating along the sides as much as a quarter-of-an-inch in thickness. It is heaviest in herbivorous animals and in man. The teeth of the carnivorae and rodents are usually very clean; this is well seen in dogs, cats, mice, and rats, though all of these, particularly when old, and also rabbits, frequently have a thin brown film even on the incisors. Some individuals are more predisposed to dental incrustation than others. This is well-known in man, and I have noticed it

in sheep, and other animals. The teeth of snakes, lizards, and fish, in so far as I have noticed, appear to be always quite free from deposit.

I do not think that the nature of the pasture, as has sometimes been asserted, has anything particular to do with the abundance or otherwise of deposit on sheep's teeth, but that it is purely a physiological idiosyncrasy. Sheep and oxen very commonly have the teeth coated with a uniform thin, dead black film, but this does not differ in composition from the thicker deposit. The common pig has very clean teeth. I have examined many hundreds of pigs' jaws, and have never noticed more than traces of a brown film.

Extended observation has satisfied me that the incrustation, in greater or less degree, is common to all mammals, and also to a number of other animals, in every case being of the same general character. I have found it, for instance, in the crocodile (*C. porosus*) Queensland, killer whales (*Orca gladiator*), and in one individual or another of practically every mammalian species examined. It will suffice to give the names of a few as indicating the scope of the investigation: tapir, eland, American bison, hippopotamus, various bears, dog, cat, rat, mouse. Examination of the skulls of marsupials in the Australian Museum collection and elsewhere disclosed numerous examples: *Macropus major*, quite as heavy as that of the sheep, *M. giganteus*, *M. rufus*, *Phascolarctus cinereus*, *Phascolomys mitchelli*, *Dasyure*, and many others. The original observations of Dr. Bennett are thus completely confirmed. Fossil marsupial teeth from Wellington Caves, New South Wales, in the Australian Museum, still have adhering brown patches which I take to be the same deposit. Wherever the teeth of animals were noticed to have a yellow or brownish tint as in aged rats, minute examination showed this to be due to the same cause.

In response to queries from me, Mr. Brown has supplied me with the following very interesting notes: "Tartar forms on artificial *plates*, especially lower plates, quite as readily as on the natural teeth; it is an everyday occurrence to see that. It is deposited along the lower portion of the lingual side of the *plate*, and dentists are continually asked by patients what it is and how to remove it. I do not remember seeing teeth forming part of a bridge with tartar deposited on them, but frequently find that the gum having slightly receded after the bridge has been fixed, a slight deposit is to be seen round the gingival margin of the natural roots to which the bridge is attached. Porcelain crowns (pivots) and gold crowns or caps remain free from deposit. I once had to remove from an elderly woman's mouth a little lower plate having three teeth on it, and there was such an accumulation of tartar all about the whole structure and the remaining teeth that two of the latter were extracted in the removal of the plate; these, however, were loose from pyorrhoea. In this case the tartar had certainly encroached to some extent on the artificial teeth. The patient informed me that she had not removed the denture since the dentist put it in place many years before This case was an exceptional one, and as I have mentioned, I do not remember seeing deposit on artificial teeth at any other time."

I think it is probable that the nature of the surface of porcelain teeth and gold crowns inhibits the adhesion of deposit. In the case of the urinary tract, it is well known that any solid foreign body, such as a piece of broken catheter, soon becomes coated with phosphate, and that a little blood clot or even bacteria may form the nucleus of a urinary calculus.—*Proceedings of the Linnean Society of New South Wales*, August 25, 1920.

THE SUBSTANCES DISSOLVED IN RAIN AND SNOW.

By WILLIAM A. MOORE and GLEN BROWNING.

THE precipitations in Mount Vernon, Iowa, from May 31 to August 13, 1920, were studied in the chemical laboratories of Cornell College. Mount Vernon is a village of about 2000 population, situated 18 miles from the nearest manufacturing centre. The rain was caught in two porcelain receptacles, about 20in. in diameter, in an open space away from trees and as far as possible from chimneys.

There were 21 precipitations during the time, and a total rainfall of 6·13 inches. The precipitations were tested for nitrogen in nitrates, nitrites, free and albuminoid ammonia. The water was also tested for phosphates, and to our surprise they were frequently found to show a trace. Sulphates were found in a number of the samples. Chlorides were found to be absent in the first two or three precipitations, and so we discontinued the tests in the later rainfalls.

We expected more than the usual amount of nitrogen in the precipitations during thunder storms, but such did not prove to be the case. For the first time in the history of these investigations carbon dioxide was sometimes detected.

When there was a small amount of precipitation, the analysis showed a relatively large amount of all the various substances. We also noticed when the wind was blowing from the manufacturing centre previous to the rainfall, there were carbon dioxide and sulphates almost invariably present.

On one occasion there were two precipitations in the same day. Both were analysed and while the first contained 0·001 parts nitrites and 0·3 parts nitrates per million, the second contained only 0·0009 parts nitrites and 0·005 parts nitrates. This decrease was always in evidence after a rain following one on the previous day.

The precipitation of the afternoon of July 4 which was 1in., contained a large amount of all the substances usually found. The ammonias were 0·6, nitrates 0·35, carbon dioxide 0·6 per million; while the average for the summer months was ammonias 0·28, nitrates 0·35, carbon dioxide, 0·23.

The amount of nitrogen as nitrites and nitrates which fell during this period of three months was 0·76lb. per acre.

In previous papers we have suggested the spray from the Atlantic Ocean borne by the winds across the country as the source of the sodium chloride in the atmosphere, and precipitations of both rain and snow. Dr. Charles T. Brooks, of Washington, D.C., editor of the *Monthly Weather Review*, kindly called our attention to dust storms and muddy rains from the arid regions of the

south-western part of the United States as a possible source of the sodium chloride in the atmosphere. He cites especially such a storm of March, 1918, described by A. N. Winchell and E. R. Miller in the *Monthly Weather Review* of November, 1918. During the storm, material was carried several hundred miles, depositing dust at Dubuque, Iowa, and various other places. Physical and microscopic examinations of the dust collected at different localities shows that it is chiefly quartz and feldspar with considerable limonite and haematite. The observers mentioned also concluded that "the dust is the product of physical disintegration and not of chemical decomposition." There is no indication that any of the observers detected sodium chloride; yet it might have been present in small quantities, and not have responded to the tests to which the deposits were subjected.

Cornell College, Mount Vernon, Iowa.
January 1, 1921.

THE CHEMISTRY AND CRYSTALLOGRAPHY OF SOME FLUORIDES OF COBALT, NICKEL, MANGANESE AND COPPER.*

By FLOYD H. EDMINSTER and HERMON C. COOPER.

(Concluded from p. 45.)

Calculations.—In the computation of the formulas for the fluorides, use was made of the analyses on crystals which were taken from the solution, washed, dried, and analysed immediately. The average of these analyses was used.

In the case of fluorine results from the precipitation by calcium chloride alone were discarded, as they had been proven to be inaccurate. The results used are the average of the fluorine determinations by titration and by precipitation by calcium chloride in the presence of calcium oxalate.

For the metal the calculations in the case of cobalt, nickel, and copper are the average of results obtained from the anhydrous sulphate and by electrolysis, with emphasis upon the latter, since in this method the sources of error are reduced to a minimum. For manganese metal the calculations are based upon the weight found in the anhydrous sulphate and in the pyrophosphate.

For the water use was made of the percentage difference.

In some cases only selected determinations were utilised for the calculations. The selection is given in the last column of the following tables. A great many more determinations were made than are recorded in the preceding tables, in order to familiarise ourselves with the possible sources of error.

Formulas.

Cobalt Fluoride.

Co = 19·40 ÷ 58·97 = 0·3291 = 1·000. All determinations.
F = 43·14 ÷ 19·00 = 2·2705 = 6·899. Nos. 90, 130, 131.
H_2O = 36·06 ÷ 18·00 = 2·0033 = 6·087. By difference.
H = 1·6.
The formula is $CoF_2.5HF.6H_2O$.

Nickel Fluoride.

Ni = 19·50 ÷ 58·68 = 0·3323 = 1·0000. All determinations.
F = 43·32 ÷ 19·00 = 2·2800 = 6·8610. Nos. 89, 96, 131.
H_2O = 35·58 ÷ 18·00 = 1·9767 = 5·9485. By difference.
H = 1·6.
The formula is $NiF_2.5HF.6H_2O$.

Manganese Fluoride.

Mn = 18·09 ÷ 55·00 = 0·3283 = 1·000. No. 76.
F = 43·02 ÷ 19·00 = 2·2640 = 6·889. No. 76.
H_2O = 35·58 ÷ 18·00 = 2·0772 = 6·327.
H = 1·5.
The formula is $MnF_2.5HF.6H_2O$.

Copper Fluoride.

(Crystals by recrystallisation from water).
Cu = 20·09 ÷ 63·57 = 0·316 = 1·000. All determinations.
F = 42·70 ÷ 19·00 = 2·250 = 7·100. All determinations.
H_2O = 35·61 ÷ 18·00 = 1·978 = 6·260. By difference.
H = 1·6.
The formula is $CuF_2.5HF.6H_2O$.

Copper Fluoride.

(Small crystals and crust deposited slowly from original mixture).
Cu = 45·82 ÷ 63·57 = 0·747 = 1·000.
F = 28·13 ÷ 19·00 = 1·480 = 2·036.
H_2O = 26·05 ÷ 18·00 = 1·440 = 2·000.
The formula is $CuF_2.2H_2O$.

We append here the results of a few determinations and calculations on the crust or powder formed in the preparation of crystals of cobalt and nickel fluorides.

Cobalt Fluoride—Crystalline Crust.

Reference No.	Fluorine Per cent.	Metal	Ratio.
84	25·09	33·99	1·0 : 2·29
			Powder.
104	24·42(a)	35·19	1·0 : 2·154

(a) Average of two determinations on the same material; fluorine also determined on same powder.

Nickel Fluoride—Powder.

100	Not det'd.	34·51	
101	25·46	34·66	1·0 : 2·26(b)

(b) Made by boiling the crust.

The results approximate the neutral salt formula and correspond to the result for the copper fluoride crust. We do not, however, feel warranted in assigning formulas.

Crystallography.

From the second recrystallisation in the open air crystals were obtained in ample quantity for crystallographic investigation and analysis. Some of them were as large as 20×8 mm. Measurements were made with a Goldschmidt reflecting goniometer. In general, the specimens were found to be extensively etched because of their high solubility. The etching caused so much dispersion of light that the reflected image was not as sharp as was desirable; therefore the readings were only reliable to about 30 seconds.

Cobalt Fluoride, $CoF_2.5HF.6H_2O$, Rhombohedral.—The cobalt fluoride is orange-red; equivalent wave length 610 $\mu\mu$ for a plate 2 mm. thick. (A considerable number of these observations were made or confirmed by H. E. Merwin, of the Geophysical Laboratory, to whom we are accordingly

*A more detailed account of this work was submitted to the Faculty of the Graduate School of Syracuse University by Floyd H. Edminster in May, 1918, in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

greatly indebted). The crystals are flattened hexagonal prisms capped by two rhombohedrons of the opposite order to the prisms. The average angle between the prism faces *m* : *m'* is 60° 0'. For the rhombohedrons the angles from the base are 30° 59' and 50° 6', both within ± 8'. From the measurements *c* = 1·039; *c* ∧ *r* (10$\bar{1}$1) = 50° 9' and *c* ∧ *e* (01$\bar{1}$2) = 30° 55'. Distinct prismatic cleavage was observed. Optically the crystals are uniaxial postive with approximate refractive indices measured by immersion: $\omega = 1·38(5)$, $= 1·39(7)$. Extinction is parallel. The sp. gr. by the Jolly balance, using alcohol as immersion liquid, is 2·0445.

It does not seem worth while to make drawings of the crystals because of their distortion, which was probably due to their growing attached by one side to the dish.

Nickel Fluoride, $NiF_2.5HF.6H_2O$, Rhombohedral.—The nickel fluoride is blue-green; equivalent wave-length 510 $\mu\mu$ for a plate 2 mm. thick; non-pleochroic, with habit, cleavage and general optical properties like cobalt fluoride. Measurements of the rhombohedrons gave the same angles as the cobalt salt. Refractive indices measured on a small prism gave the following results for the mercury lines; the other values are interpolated:

	ω	ϵ
Hg 436	1·398	1·413
F	1·395	1·410
Hg 578	1·392	1·408
D	1·392—	1·408—
C	1·390	1·406

Sp. gr. in alcohol, 2·0006.

Manganese Fluoride,[1] $MnF_2.5HF.6H_2O$.—The manganese fluoride is light red with habit and general optical properties like those of cobalt fluoride. The average angle between the prism faces *m* : *m* is 60° 8'. The pyramid faces were so poorly developed that it was impossible to measure them. Sp. gr. in alcohol, 1·921.

Copper Fluoride, $CuF_2.5HF.6H_2O$, Monoclinic. —The copper fluoride is blue-green-blue, equivalent wave-length 490 $\mu\mu$ for a plate 2 mm. thick, and is distinctly pleochroic. The crystals were not perfect enough to determine by form. Microscopically they apparently show three cleavages, to one of which they extinguish parallel. This cleavage seems to be parallel to a set of faces. The extinction observed against another apparent cleavage is very oblique. A few elongated rough crystals and cleavage fragments were elongated in the direction of α'. Good biaxial interference figures showed $-2E = 48° \pm 2°$, with no observable axial dispersion. The refractive indices were measured carefully under the microscope by immersion as follows: $\alpha = 1·395$, $\beta = 1·440$, $\gamma = 1·444$. Therefore, $-2V = 32°$. α is least absorbed.

The evidence of monoclinic symmetry is thus almost conclusive. The examination of the optical properties was rendered very difficult by the rapid loss of crystal hydrate water. Sp. gr. in alcohol, 2·4055.

The crystals of the normal fluoride, $CuF_2.2H_2O$, were too small to measure. Recrystallisation yielded the acid fluoride.

Isomorphism.—The chemical and optical examination thus showed that the acid fluorides of cobalt, nickel, and manganese are isomorphous, while the similarly prepared copper fluoride, of the same chemical formula, has a different crystal form. The first three are rhombohedral, forming flattened hexagonal prisms, capped by two rhombohedra of the opposite order to the prisms. All three showed prismatic cleavage, are uniaxial positive, and give parallel extinction. The refractive indices of the cobalt and nickel fluorides differ by less than 1 per cent. The indices of the manganese fluoride were not measured.

Summary.

The fluorides of cobalt, nickel, manganese, and copper can be prepared by dissolving either the hydroxide or the carbonate of the metal in hydrofluoric acid, the same product being obtained, whichever is used. In all cases a crust-like product was obtained as the result of evaporating the original solution. From the water extract, slightly acidulated with hydrofluoric acid, crystals of the acid fluorides were formed and analyses and measurements of these crystals were made.

The formulas of all four fluorides are of the same acid fluoride type: $MF_2.5HF.6H_2O$. It was a surprise to obtain the acid fluoride by recrystallisation from water, it being considered more likely that a basic salt would be obtained under these circumstances.

The acid fluorides are not permanent in the air, but decompose, losing hydrogen fluoride, and in the case of copper losing water also, so that the crystals used for analyses must be carefully selected and preserved. Investigation of the rate of loss of hydrogen fluoride was not undertaken, but our analyses were made with crystals soon after being taken from the solution and in our opinion the results are the most reliable obtainable.

The formation of a hydrated, non-crystalline crust is distinct from that of the hydrated acid fluoride crystals. In this crust the ratio of metal to fluorine, for the cases of cobalt and nickel, was found to be, roughly, one to two, with varying water content. This crust differs from the crystals in solubility and form, as well as in composition. We have arrived at the conclusion that the crust described by Berzelius as containing two molecules of water, the crust later described by Clarke as containing three molecules of water, and the crust and powder obtained by use are the same, the water content being variable and the crystal form undeveloped. All were obtained in the same manner.

The acid fluorides of cobalt, nickel, and manganese give rhombohedral crystals, with prismatic cleavage, parallel extinction and uniaxial positive character. Since they have the same type of chemical formula, the same crystal form and the same habit, cleavage and general optical properties, we consider that they constitute an isomorphous series.

The acid fluoride of copper has the same type of formula, but differs crystallographically.

From the original preparation of copper fluoride small crystals of the normal fluoride, $CuF_2.2H_2O$, were obtained, which were not good enough for measurement and which reverted unexpectedly to the acid fluoride on recrystallisation from water.

The experimental work upon which this article is based was completed in May, 1918.

ON FERRAZITE? A NEW ASSOCIATE OF THE DIAMOND.

By T. H. LEE and LUIZ FLORES DE MORAES.

Among the voluminous researches of the late Eugen Hussak, some of the most interesting are his patient investigations of the dense minerals found in diamond-washing, which extended over a number of years.

Apart from the great number of minerals studied and determined by him and made known to the scientific world by the publication of his posthumous work "Os satellites do Diamante," edited by our colleague Dr. Jorge Belmiro de Araujo Ferraz, considerable and valuable material exists in the Hussak mineral collection, acquired and conserved by the Brazilian Geological Service, in which our colleague encountered and handed to us for analysis a number of "favas" with Hussak's own label "Pb-Al hydrophost. D.-3·095. Neu! (*Favas*: English equivalent "Beans." This name is applied to certain dense rounded flattish pebbles found with the dense residues from gravel in the diamond-washers batéas).

From the results of a preliminary analysis it appeared that, in addition to lead, barium was also present, which led us to carry out a complete analysis, leading to the following results:—

Combined water	14·20
Lead oxide	45·63
Barium oxide	8·87
Lime	traces
Alumina	3·48
Phosphoric Anhydride	26·24
Silica	2·44
	100·86

Considering the silica to be present as kaolinite, and the excess of alumina over and above that required by the silica to be present as wavellite, the composition of the "favas" should be represented as follows:—

	New Mineral	Kaolinite	Wavellite
Combined water	12·48	0·71	1·01
Lead oxide	45·63	—	—
Barium oxide	8·87	—	—
Alumina	—	2·05	1·43
Phosphoric anhydride	24·92	—	1·32
Silica	—	2·44	—

Calculating anew the composition of the new mineral on a centesimal basis, we have:—

		Molecular ratios.
Combined water	13·58	0·7544
Lead oxide	49·65	0·2227
Barium oxide	9·65	0·0631
Phosphoric anhydride	27·12	0·1910
	100·00	

Recalculating these molecular ratios on a basis of P_2O_5 equal to 2, we have:—

Combined water	7·900
Lead and barium oxides	2·993
Phosphoric anhydride	2·000

or 3 $(Ba,Pb)O.2P_2O_5.8H_2O$.

The density of the "favas" varies between 3·0 and 3·3. The colour is a dark yellowish-white, resembling that of old ivory. The specimens are discoid in shape, and thin sections show under the microscope a granular structure suggesting that resulting from the evaporation of a colloid substance.

Dana's "System of Mineralogy," 6th ed. with Supplements I. and II., mentions no such mineral, although it includes all Damour's results, so that we feel justified in claiming novelty for the mineral, and suggest for it the name of *Ferrazite*, in just recognition of Ferraz's valuable work in editing Hussak's posthumous work, and in classifying and rendering available the precious mineral collection left by him.—*American Journal of Science*, xlviii., p. 353.

THE CRYSTAL STRUCTURE OF ICE.

By D. M. DENNISON.

Synopsis.

Crystal Structure of Ice as Determined from X-ray Pattern.—A small sample of ice composed of minute crystals, gave by Hull's method a pattern of 12 clearly-defined lines whose positions indicate that the lattice of an ice crystal corresponds to a hexagonal close-packed arrangement of molecules, consisting of two sets of interpenetrating triangular prisms with sides 4·52 A and height 7·32 A. Since for close-packed spheres the axial ratio should be 1·633 instead of 1·62, the ice molecules act like spheres which have become flattened by 0·8 per cent in the direction of the hexagonal axis. This lattice is practically the same as that found for magnesium, but the differences in relative intensity between the lines of the two X-ray patterns suggest that ice molecules and magnesium atoms must differ considerably in shape.

Molecular Formula for Ice.—From the density of ice and the dimensions of the lattice it follows that the formula for an ice molecule is $(H_2O)_2$ or H_4O_2.

X-ray photographs of ice were made in the same manner as the crystal powder photographs described by W. A. Hull (*Phys. Rev.*, Jan. 1917, ix., 85). A small quantity of distilled water was enclosed in a thin-walled capillary tube of lime glass. The tube was then plunged quickly into liquid air, freezing the water with such rapidity that only very minute crystals were formed. The tube was then kept at liquid air temperature in a specially constructed Dewar flask. The sample was rotated continuously during the 10-hour exposure to the X-rays from the molybdenum target of a water-cooled Coolidge tube which was running at 32,000 volts, 25 milliamperes direct current. The photographic film was bent in a semicircular arc of radius 19·8 cm. The tube of ice was placed in the axis of this arc. A good photograph was obtained which contained 12 lines, the data from which are recorded in the table.

The first column gives the angular deviation of each line, the second gives the intensities, which were only roughly estimated, and the third gives the intensities of the corresponding magnesium lines as estimated by Dr. Hull (*Pro. Nat. Acad. Sci.*, July, 1917, iii., 470). The fourth column gives the observed plane spacings, while the fifth gives the theoretical plane spacings which would correspond to a close-packed hexagonal lattice,

consisting of two sets of interpenetrating triangular prisms, the sides of whose bases are each 4.52 Ångstroms and whose height is 7·32 Ångstroms. The observed and theoretical spacings agree within the limit of experimental error.

Angular Deviation of Line 2θ (Degrees).	Intensity of Line (Estimated).	Intensity of Magnesium Line for Comparison.	Spacing of Planes in Ångstroms Obs.	Cal.	Indices of Form.	No. of Coöperating Planes.
10·44	1	4·7	3·92	3·915	1010	3
11·16	10	—	3·67	3·671	0001	1
11·88	2	10·0	3·44	3·453	1011	6
15·30	1·5	3·3	2·68	2·675	1012	6
18·12	1	4·7	2·26	2·260	1120	3
19·86	5	4·0	2·065	2·065	1013	6
21·38	1	4·0	1·92	1·925	1122	6
27·16	1·5	1·0	1·516	1·528	2023	6
30·20	2	1·3	1·368	1·372	1015	6
			1·368	1·372	1232	12
31·76	0·25	0·2	1·30	1·305	1010	3
33·08	0·25	1·0	1·25	1·268	1233	12
35·54	0·5	0·3	1·167	1·165	2025	6

The above values give an axial ratio of 1·62 in good agreement with the crystallographer's value of 1·617 (Gmelin Kraut, "Handbuch der Anorganischen Chemie," Heidelberg, 1907, i., 1, p. 107). An hexagonal lattice of close-packed spheres has an axial ratio of 1·633. The data from the photograph seem to indicate that 1·62 is a more probable value than 1·633 for the structure of ice. This ratio and the dimensions of the elementary prism were determined by means of a set of graphs, made by Dr. Hull and Dr. Davey, which is to be published shortly.

Estimating p the density of ice at liquid air temperature as $p=0·944$, the number N of molecules of H_2O per cubic centimetre may be calculated.

$$N = \frac{p(6·023) \times 10^{23}}{18} = 3·154 \times 10^{22}.$$

The volume V of the elementary prism may also be found, knowing that a the base and h the height of the prism are 4·52 A. and 7·32 A. respectively.

$$V = \frac{\sqrt{3}a^2h}{4} = 0·6478 \times 10^{-22}\text{c.c.}$$

The number n of H_2O molecules per unit prism is then equal to the product VN.

$$n = VN = 2·04.$$

Ice belongs then very nearly to one of the two alternate arrangements which inelastic uniform spheres may assume if packed as closely as possible. This is the same form that magnesium atoms take. If the molecules of ice and the atoms of magnesium were identical in arrangement and form, not only would the plane spacings be proportional but also the intensities of the lines would be similar. From columns two and three of the table it may be seen that the intensities are not proportional. With increased knowledge of crystal structure these data may furnish information regarding the shape of the molecule of water. With the hexagonal close-packed type of lattice each prism contains on the average one molecule. The result calculated above indicates that in ice crystals the molecules of water are of the form $(H_2O)_2$ or H_4O_2.—*Physical Review* (*U.S.A.*), January, 1921.

THE LUMINESCENCE OF SAMARIUM.

By HORACE L. HOWES New Hampshire State College.

THE rare earth elements, in composition with lime or other diluents have been made to phosphoresce by Sir William Crookes (Crookes, *Comptes Rendus*, 1879, lxxxviii., 283), Leecoq de Boisbaudran (Leecoq de Boisbaudran, *Comptes Rendus*, 1885, ci., 552), Urbain (Urbain, *Annales des Chimie et de Physique*, 1909, ser. 8, xviii., 222), and others. The most favoured mode of excitation is by the cathode rays. The long controversy between Urbain and Crookes over the phosphorescent spectra of the rare earths has resulted in the control of those exacting chemical processes whereby the rare earths can be prepared in definite grades of purity. Such beautiful analyses have been made that the physicist is now able to begin his study of the rare earths with an exact knowledge of the composition. The method of making samples for luminescence (using the term "luminescence" to include the older terms "phosphorescence," as well as "fluorescence") can be varied systematically, the heat treatment well controlled, and the variation of the spectra, if present, noted. As has always been found true, heat treatment is necessary to render the specimen in a luminescent condition. The molecular aggregates are no doubt so changed by the heat treatment that luminescent centres are produced in highly localised positions scattered through the general structure.

One of the chief reasons why the rare earths in solid solution offer an excellent field for attacking the problem of luminescent radiation is because of the highly resolved bands which constitute the luminescence spectrum. Hitherto, with the exception of such solids as the uranyl compounds and the ruby and such gases as iodine, sodium, mercury, sulphur, &c., studies have been made with substances, which, although brilliant, exhibit only broad bands. The difficulties in the path when analysis of such very broad bands is attempted are considerable because of the extensive overlapping of the components, but the rare earth compounds present—like the uranyl compounds where very narrow bands are viewed against a dark background—a very convenient field (Nichols and Howes, "The Fluorescence of the Uranyl Salts," *Publications of the Carnegie Institute of Washington*, No. 198). The present work on samarium must be considered a prelude to a rather complete analysis of rare earth luminescence.

The present problem was the outcome of earlier work done in collaboration with Prof. E. L. Nichols and the investigation was made possible by a grant from the Rumford Fund. The specimens of samarium oxide were obtained from Prof. C. James, of New Hampshire State College, and the solid solutions were prepared by Dr. D. T. Wilber, of Cornell University. The samarium oxide was weighed and dissolved in hydrochloric acid and diluted to 1/100. This solution was added to pure calcium carbonate which had previously been tested for non-luminescence in a proportion which gave one atom of rare earth to 125 atoms of calcium. The mixture was evaporated to dryness with stirring. The heat treatment was carried on in the following manner: limited portions were placed in uncovered glazed crucibles and treated at several temperatures between 200°

and 1200° C. in an electrical resistance furnace. The duration of heat treatment at one temperature was also varied between one and three hours. It was found that it was necessary to heat to a critical temperature of approximately 600° C., to render the luminescence sufficiently bright for spectrum analysis when the specimen was subsequently cooled to +20° C. and excited by the cathode rays. The 200° C. specimens gave no luminescence at all and the 400° C. specimens exhibited but few regions of luminescence. As regards the duration of heat treatment, one hour served as well as three hours—probably because only thin layers were treated. About twenty specimens from the same stock were thus heat treated, and finally one specimen was heated five minutes in the core of an arc carbon. Although no quantitative measurements of intensity were taken it was observed that specimens previously heated to 1200° C., or above that temperature, were the most brilliant under cathode rays at +20° C.

The luminescence spectrum consists of more than thirty bands of varying intensities, which plotted to a frequency scale can be resolved into several series: *a, b, c, d, e, f, g, h, i,* of constant frequency intervals. The intervals, although constant for given series, vary slightly from one series to another; series *a* for example of 110 units interval, series *b* of 108 units interval. In Table I. will be found the wave-length and reciprocal of wave-length of each band together with the relative intensity and series letter. The bands not previously discovered are marked, but the object of the present investigation was to study the conditions under which the spectrum is produced and to analyse it—rather than to discover new bands. The times required for one exposure averaged approximately ten minutes.

TABLE I.

Luminescence Bands of Samarium Oxide in Calcium Oxide.

Nature.	λ.	1/λ	Series.
v.d.	6801	1470	*c*
d.	6734	1485	*d*
v.v.d.	6643*	1505	*e*
d.	6600	1515	*a*
d. br.	·6536	1530	*f*
d	6470	1546	*b*
d. Vag.	6405	1561	*h*
d. br.	6329	1580	*c*
m. br.	6270	1595	*d*
m. Va.	6183*	1617	*e*
V.*str.*	6146	1627	*a*
v.d.n.	6140*	1629	*a'*
v.d.	6103	1639	*f*
v.str.	6050	1653	*b*
v.v.d.n.	5990*	1669	*h*
m	5940	1684	*c*
v.d.v.n.	5898*	1695	*g*
m. b.:	5868	1705	*d*
m	5793	1726	*e*
v. str.	5757	1737	*a*
v.v.d.n.	5721	1748	*f*
v. str.	5675	1762	*b*
d.	5653*	1769	*i*
v.d.	5621*	1779	*h*
d.Vag.	5581*	1792	*c*
m	5553	1801	*g*
v.d.n.	5520*	1812	*d*
n.	5481	1824	—
v.d.n.	5451*	1835	*e*
v.d.n.	5416*	1846	*a*
v.d.br.	5387*	1856	*f*
v.d.br.	5328*	1877	*i*

* Wave-lengths of bands hitherto undiscovered.

The most startling behaviour of the samarium oxide rests in the fact that *no shift in the positions of the bands could be measured, whether the specimen was heat-treated at* 600° C. *or* 3000° C. This remarkable stability is *not* generally associated with a luminescent substance, and hence is of great importance. It may be due in part to the greater than ordinary purity of the materials employed as well as to consistency in the conditions of excitation, exposure, &c.

The specimens must be kept in a desiccator or sealed in glass since both the samarium and calcium oxides upon taking water from the air become non-luminescent as a compound. The specimen was mounted on an aluminium shelf which tended to keep the temperature from rising much above room temperature by conducting the heat due to impact to a hollow aluminium cylinder of large area. That this precaution served the purpose of maintaining the temperature of the very thin lamina of the specimen near room temperature was observed in a unique manner. After an exposure it was observed that a small portion of the cathode ray bundle did not strike the specimen but passed on to excite the luminescence particles of the specimen which had fallen to the bottom of the glass tube. When the cathode stream was stopped the particles on the glass surface exhibited brilliant thermo-luminescence due to heating by the cathode rays while the sample on the aluminium shelf showed no thermo-luminescence.

Subsequently it was found that the temperature required for thermo-luminescence was approximately 200° C.

Summary.

1. The spectrum of the cathode-ray luminescence of samarium oxide in calcium oxide is unchanged by heat treatment at several temperatures ranging from 600° to 3000° C.

2. The spectrum consists of eight short series of constant frequency intervals.—*Physical Review (U.S.A.)*, January, 1921.

PROCEEDINGS OF SOCIETIES.

MINERALOGICAL SOCIETY.

January 18, 1921.

"*The Olivine Group.*" By A. F. HALLIMOND.

Since the discussion of the densities by Thaddéef in 1896, and of the optical constants by Backlund in 1909, numerous additions have been made to the published data. These have been collected, and the most probable values for the pure compounds obtained. The molecular volume of monticellite is slightly greater than the mean between forsterite and γ-Ca_2SiO_4. For the complex mixtures the density and mean refractive index yield additive relationships, but the birifringence and axial ratios follow no additive law. The conditions of plotting which must be observed

if the variation of an additive property with composition is, to be expressed by a straight line were briefly summarised.

"A Method of Rock-Analysis Diagrams Based on Statistics." By W. A. RICHARDSON.

Oxide variation diagrams, similar to those employed by Dr. Harker, can be used for expressing the chemical relations of rock groups and individuals. The diagrams obtained from plotting Iddings' selected analyses gave the maximum variation for all rocks.

"Identity of Trechmann's 'β-tin' with Stannous Sulphide." By L. J. SPENCER.

A re-examination of the original material described by C. O. Trechmann in 1879 as an orthorhombic modification of tin proved that he made his crystallographic determinations on crystals of one kind (viz., stannous sulphide), whilst the chemical analysis was made on crystals of another kind (viz., metallic tin). Tin is therefore dimorphous and not trimorphous, "white tin" being tetragonal, and "grey tin" cubic. Orthorhombic crystals of stannous sulphide (SnS) and tetragonal crystals of iron stannide ($FeSn_2$) from tin furnaces, and rhombohedral crystals of tin arsenide (Sn_3As_2) isolated from a tin-arsenic alloy were described.

THE SOCIETY OF GLASS TECHNOLOGY.

Wednesday, January 19, 1921.

DR. M. W. TRAVERS, F.R.S., in the Chair.

The Fortieth Meeting of the Society of Glass Technology was held in the Mappin Hall, Applied Science Department, The University, Sheffield.

The first paper presented was entitled :—

"The Rate of Change of Glass Composition in a Tank Furnace following a Change in the Batch Composition." By JOHN CURRIE, M.A.

In this paper, which was given by Prof. W. E. S. Turner, the author stated that the tank furnace in question had a dead-weight capacity of 106 tons. During six working days in the week, filling on took place every two hours, the quantity added being made up of 30cwt. of batch and 4cwt. of cullet, derived directly from the working end. Originally, the metal in this tank was used for bottles made on Forster machines. In place of these there were installed semi-automatic O'Neill machines, with Hartford-Fairmont feeder. It was thus necessary to produce a glass of lower melting point and slower rate of setting. The batch was altered accordingly, so as to reduce the percentage of lime, at the same time increasing the percentage of alkali in the glass. At various dates after the new batch was put into use, a sample bottle was taken for analysis, and the density of the glass was also determined.

The main fact established in the paper was that a period of nearly three months was required to effect a radical change in the composition of the tank. After that period, the composition of the glass was nearly identical with that calculated from the new batch, the percentage of lime being 7·42 as compared with 6·78 in the theoretical composition.

The discussion that folowed this paper was exceptionally interesting, those taking part being the Chairman, Messrs. R. L. Frink, W. J. Rees, G. Simpson, J. H. Davidson, A. E. Hill, J. Connolly, and Th. Teisen. In the absence of the author, Prof. Turner replied.

Two other papers were presented, namely :—

(a) *"Problems arising in Tank Furnace Practice through Shortage of Saltcake."* By PROF. W. E. S. TURNER.

(b) *"The Relative Advantages and Disadvantages of Limestone, Burnt Lime, and Slaked Lime as Batch Materials."* By F. W. HODKIN, B.Sc., and PROF. W. E. S. TURNER.

These two papers were taken together, and presented by Prof. Turner. The relative advantages of saltcake and soda ash were discussed. It was pointed out that soda ash was generally much purer than saltcake, that it gave glass a considerably greater proportion of its weight than did saltcake, and that soda ash batch would melt more rapidly and readily than a saltcake batch. It was also alleged that saltcake had a more corrosive action than soda ash on the refractory materials of the furnace. Further, soda ash was usually transported on the railways more carefully than saltcake. The price had also to be considered, and an answer given to the question as to what happened when saltcake could not be got. Various substitutes had been tried with success. In some cases one-half or two-thirds of the saltcake had been replaced by a corresponding amount of soda ash. Attention was directed to an observation made by Mr. Golstharp, chemist to the Pittsburgh Plate Glass Co., U.S.A., to the effect that a good clear glass, having more than a certain lime content, could not be made with a wholly soda ash batch.

A number of lantern slides were presented showing the results of experiments made with small melts in which there were tried soda ash and saltcake batches, and also a mixture of these. In these experiments, they had tried in turn as the source of the alkali in the glass (1) limestone, (2) burnt lime, and (3) slaked lime. What resulted depended in a considerable degree upon the nature or form in which the lime was placed in the batch. In addition, there were other factors. Burnt lime may be expensive, but the burning of lime did not get rid of organic matter which had a reducing action in the tank, and therefore tended to make the colour poor. On the other hand, there were difficulties in handling burnt lime, while it also readily absorbed moisture and carbon dioxide. Limestone tended to make a batch more expensive, but when melted it gave off a considerable quantity of gas, which helped mechanically to stir up the glass, thereby giving greater homogeneity.

A discussion followed, in which there took part the Chairman, Messrs. W. J. Rees, R. L. Frink, G. Simpson, and J. Connolly. Mr. Hodkin and Prof. Turner replied.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxxi., No. 23, December 6, 1920.

SPECTRUM ANALYSIS. Table of the most persistent lines of the elements, which should help in analysis.—M. A. DE GRAMMONT.—This work is the outcome of work carried out by the author during the last few years for many industries and Government Departments. The *raies ultimes* are designated by the symbols $_{u1}$, $_{u2}$, $_{u3}$, showing their order of persistence, $_{u1}$ being the last to disappear. The dominant lines are printed in heavy type, and those which are next in order are printed in ordinary type. The wave-lengths in the table are expressed in international Angström units. A certain number of the visible lines, principally those lower than 4800, have been placed in the column *crown uviol glav spectrograph* because they have been determined with this apparatus.

Chemical Notices from Foreign Sources.—THE DOMINANT LINES IN THE SPECTRUMS OF THE ELEMENTS.

			By Photography.	
		Visible Portion.	*"Uviol Crown" Glav Spectrograph.*	*Quartz Spectrograph.*
Aluminium		6245·1; 6233·8	**3961·5**$_{u1}$; **3944·0**$_{u}$	3092·7; 3082·2
Antimony			3267·5; 3232·5	**2598·1**$_{u}$; **2528·5**$_{u}$; 2311·5
Argon	(1)			
Arsenic				2860·5; **2780·2**$_{u}$; 2745·0; **2349·8**$_{u}$; 2288·1
Barium		5535·5	**4934·1**$_{u2}$; **4554·0**$_{u1}$; 3891·8	2335·3
Bismuth		4722·5		**3067·7**$_{u1}$; 2989·0; 2938·3; **2898·0**$_{u2}$; 2780·5
Boron			3451·4	**2497·7**$_{u}$; **2496·8**$_{u}$
Bromine	(2)			
Cadmium		6438·5; 5085·8; 4800·0	3610·5; 3261·1	2748·6; **2288·0**$_{u2}$; **2265·0**$_{u1}$; 2144·4
Cæsium			**4593·2**$_{u}$; **4555·4**$_{u}$	
Calcium			**4226·7**$_{u3}$; **3968·5**$_{u2}$; **3933·7**$_{u1}$	
Carbon			4266·9	**2478·6**$_{u}$; 2296·9
Cerium	(4)		4186·6; **4040·9**$_{u}$; **4012·6**$_{u}$	
Chlorine	(2)			
Chromium		5208·4; 5206·1; 5204·5	4289·7; 4274·8; **4254·3**$_{u}$; **3605·3**$_{u}$; **3593·5**$_{u}$; 3578·7	
Cobalt		5353·5; 5342·7	**3453·5**$_{u}$; **3405·1**$_{u}$	**2388·9**$_{u1}$: **2378·6**; 2363·8; 2311·6; 2307·9; 2286·2
Columbium			4101·0; **4079·7**$_{u}$; **4059·0**$_{u}$; 3358·4	
Copper		5218·2. 5153·3; 5105·6	**3274·0**$_{u2}$; **3247·5**$_{u1}$	
Dysprosium	(1)			
Erbium	(4)		3906·3; 3692·7; 3499·1	
Europium			4205·1; **4129·8**	
Fluorine	(2)			
Gadolinium	(1)			
Gallium			**4172·1**$_{u1}$; 4033·0	
Germanium			**3269·5**$_{u2}$	**3039·1**$_{u1}$; 2651·4
Glucinum			3321·4; 3321·1	**3131·1**$_{u1}$; **3130·4**$_{u}$
Gold		6278·2: 5837·4; 4792·6		2802·2; **2676·0**$_{u1}$; **2428·0**$_{u}$
Helium	(1)			
Holmium	(1)			
Hydrogen		**6562·8**$_{u}$		
Indium			**4511·4**$_{u1}$; **4101·8**$_{u2}$	
Iodine	(2)			
Iridium	(4)		**3513·7**$_{u}$; 3437·1; **3220·8**$_{u}$	
Iron		4404·3: 4383·6	4045·8; 3820·4; 3737·1; 3734·9; 3570·2; 3565·4	**2755·7**$_{u}$; **2749·3**$_{u}$; **2739·6**$_{u}$ **2395·6**$_{u2}$; **2382·0**$_{u1}$
Krypton	(1)			
Lanthanum	(4)		4333·8; 4086·7; 3995·8; 3988·5; **3949·1**$_{u}$	
Lead		5608·9; 5005·5	**4057·8**$_{u1}$; **3683·5**$_{u2}$; 3639·6	2614·2; 2203·6; 2175·8
Lithium		**6707·9**$_{u}$	**4602·2**$_{u}$	
Lutecium	(1)			
Magnesium		5183·6; 5172·7; 5167·3	3838·3; 3832·3	**2852·1**$_{u1}$ (1); **2802·7**$_{u2}$; **2795·5**$_{u3}$
Manganese		4283·6; 4783·5; 4754·1	4034·5; 4033·1; **4030·9**$_{u2}$	2605·7; **2593·7**$_{u}$; **2576·2**$_{u1}$
Mercury		5460·7; 4358·3		**2536·5**$_{u}$
Molybdenum		5570·5; 5533·2; 5506·5	**3903·0**$_{u}$ (3): **3864·1**$_{u}$; **3798·3**$_{u}$ (3); 3635·2	
Neodymium	(3)		4303·6; 4177·3; 3951·2	
Neon	(1)			

			By Photography.	
		Visible Portion.	*"Uviol Crown" Glav Spectrograph.*	*Quartz Spectrograph.*
Nickel		5476·9; 5081·1; 4714·4... ...	3619·4; 3524·5; 3515·1; 3414·8$_u$; 3380·6	2437·8; 2416·2$_{u1}$; 2316·1$_u$; 2303·0$_u$
Nitrogen ...	(2)			
Osmium ...	(1)			
Oxygen ...	(2)			
Palladium ...	(4)		3634·7$_u$; 3609·6$_u$; 3421·2; 3404·6$_u$	
Phosphorus				2555·0; 2553·3$_u$; 2535·6$_u$; 2534·0
Platinum ...	(3)	5475·8; 5390·8; 5301·6; 5227·6	3966·4$_u$; 3923·0; 3268·4 ...	3064·7; 2929·8; 2734·0; 2659·4
Potassium ...		5832·0; 5801·8; 5782·4... ...	4047·2$_{u1}$; 4044·2$_u$; 3447·4; 3446·4	
Præsodymium	(1)			
Radium ..	(1)		(4285·9; 4682·2; 3814·5) (²)...	
Rhodium ...	(4)		3799·3; 3692·4; 3658·0; 3434·9$_u$	
Rubidium ...			4215·6$_{u2}$; 4201·8$_{u1}$	
Ruthenium...	(4)		3499·0$_u$; 3436·7	
Samarium ...	(1)			
Scandium ...	(4)		4246·9; 3651·9; 3613·8$_{u1}$; 3630·8$_u$	
Selenium ...	(2)			
Silicon... ...		6370·9; 6346·8; 5057·0; 5042·3		2881·6$_u$; 2528·5; 2516·1$_u$; 2506·9
Silver		5465·5; 5209·1	3383·0$_{u2}$; 3280·7$_{u1}$	2437·7
Sodium ...		5895·9$_{u1}$; 5890·0$_{u1}$	3303·0$_{u2}$; 3302·4$_{u2}$	
Strontium ...			4607·3$_u$; 4305·5; 4215·5$_{u2}$; 4077·8$_{u1}$	
Sulphur ...	(2)			
Tantalum ...	(3)	6045·5; 5997·4	3631·9; 3406·9; 3318·8; 3311·2$_u$	2963·4
Tellurium ...				2769·8; 2530·8; 2385·8$_{u1}$; 2383·3$_{u2}$
Terbium ...	(1)			
Thallium ...		5350·5$_{u1}$	3575·7$_{u2}$; 3519·2; 3229·8 ...	2767·9
Thorium ...	(4)		4019·1; 3601·1; 3539·6... ...	
Thulium ...	(1)			
Titanium ...		green group (5014.3 to 4981.8)	3372·8$_u$; 3361·2$_u$; 3349·4$_{u1}$ ...	
Tin		524·7	3801·0; 3330·6; 3262·3$_u$ ...	2863·3$_u$; 2840·0; 2706·5
Tungsten ...	(3)		4302·4$_{u1}$; 4294·7; 4008·8$_u$; 3613·8; 3215·6$_u$	2397·1
Uranium ...	(2)			
Vanadium ...	(3)		4408·5; 4379·2; 3185·4; 3184·0; 3183·4	3110·7; 3102·3; 3093·1
Xenon	(1)			
Neoytterbium	(4)		3988·0$_{u2}$; 3694·2$_{u1}$; 3289·4 ...	
Yttrium ...	(4)		3774·3$_{u2}$; 3710·3$_{u1}$; 3633·1; 3600·7$_{u3}$; 3242·3	
Zinc		6362·3	4810·5$_{u3}$; 4722·2$_{u2}$; 4680·2; 3345·0$_{u1}$	2138·5
Zirconium ...		blue group (4815·5 to 4687·8)	3496·2$_u$; 3438·2; 3392·0$_{u1}$ ...	

(1) Not studied by the Author.
(2) Does not give either the "raies ultimes" or the dominant lines.
(3) In course of study; provisional results.
(4) Studied only in the crown uviol; provisional results.
(¹) Masked by Sodium 2852·8.
(²) Runge and Precht.
(³) Masked by the Iron lines.

MEETINGS FOR THE WEEK.

Monday, February 7, 1921.

Royal Institution, 5. (General Meeting).
Society of Chemical Industry, 8.

Tuesday, February 8.

Royal Institution, 3. "The British Soldier since the Restoration—In War," by Hon. J. W. Fortescue.
Institution of Electrical Engineers, 7. (At Leeds).
Institute of Metals, 8. (At Glasgow).
Royal Society of Arts, 8. "The Problem of Unemployment," by E. C. de Segunds.

Wednesday, February 9.

Conjoint Board, 3.
Royal Society of Arts, 4.30.

Thursday, February 10.

Royal Institution, 3. "Oceanography—Problems of the Plankton," by Prof. W. A. Herdman.
Society of Chemical Industry. (At Birmingham).
Institute of Chemistry. (At Liverpool).
Optical Society, 7.30.

Friday, February 11.

Royal Institution, 9. "Isotopes and Atomic Weights," by Dr. F. W. Aston.
Physical Society, 5. (Annual Meeting).
Faraday Society and Manchester Literary and Philosophical Society, 6 30. (At Manchester).

Saturday, February 12.

Royal Institution, 3. "Spectroscopy—Experimental Spectroscopy," by A. Fowler.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

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THE CHEMICAL NEWS.
VOL. CXXII., No. 3174.

EDITORIAL.

We have recently drawn attention to the importance of glassware in the chemical industry, and to the efforts that are being made by British glass manufacturers to render the country independent of foreign supplies.

The Association of British Chemical Manufacturers have recently issued a statement pointing out the gravity of the situation as regards the production of fine chemicals which we are glad to publish, as these matters are of supreme national importance if we are to hold our own in the near future. Recent developments in Germany, both in home politics and in trade propaganda enhance the importance of increasing vigilance at the present moment

A KEY INDUSTRY.

Are Britain's Laboratories in peril? The Association of British Chemical Manufacturers draws attention to the present position of the Fine Chemical Industry.

The next month or so will decide whether, in the years to come, Great Britain is to make fine chemicals for all the world, or whether we and the other nations are once more to turn to Germany for our laboratory and photographic chemicals, for essential drugs like antipyrin, phenacetin, cocaine, salicylates, aspirin, salversan, and others.

The case against buying these fine chemicals from the Germans is not founded on any foolish post-war prejudice against trading with a former enemy. It is a matter of international principle only less grave than the surrender of the High Seas Fleet and the reduction of the German Army. To-day it should not be necessary to remind any British citizen that it was Germany's phalanx of expert chemists with their experienced workmen who gave her so tremendous an advantage in the early days of the struggle. That military asset was, of course, the direct consequence of the fact that Germany had been chemical maker to the world; nor for several reasons was it possible in those days to compete with the laboratories which in a night were to become munition factories. For one thing, Germany had built up what was practically a monopoly in the fine chemical industry because the raw materials for that industry are largely the bye-products of the dye-stuffs industry —by that time, of course, almost a German monopoly.

Mobilising the Chemists.—The war found her supreme, both in the necessary plant and in the knowledge, not readily acquired, of the most economical mode of production. But it did not leave her supreme; and it will be strange if we have since forgotten what we then learnt, namely, the unwisdom of leaving in the hands of any one nation the supply of drugs essential to our health, especially when that surrender places ready to her hand the plant needed for the manufacture of explosives and the chemists and the workmen skilled in its use.

The position amongst us to-day may be simply stated. During the war we assembled from our polytechnics, colleges, and universities, men who, after much striving and many failures, did arduously acquire not only a knowledge of the explosives which destroy life, but of certain drugs, such as phenacetin, salicylates, and salversan that save it. But the plant which was then rigged up was emergency plant; the methods were emergency methods—in the circumstances, naturally expensive. Are we for these reasons to permit our little army of chemist experts to be scattered? Are we to hand back to Germany an industry so lucrative in time of peace and potentially so formidable for war?

The Making of Medicines.—Or should we give ourselves a chance? It must not be imagined that our men have failed to make good. They have made good; or rather they are just on the point of doing so. The manufacture of research chemicals, of photographic chemicals, of synthetic perfumes and essences is each on the verge of commercial success. The manufacture of drugs has made immense strides; many; begun some time ago, have been brought to perfection; others had been added or were being added when the decision of Mr. Justice Sankey was dropped like a bomb into the thick of these experimentings. British manufacturers had proved that they could make fine chemicals as good as the fine chemicals of Germany, and they were slowly but quite surely bringing down the cost of making them, when suddenly the Order in Council prohibiting the importation of drugs was swept aside.

What has been the effect? Germany, it must be remembered, had long ago arrived at the point to which this new industry of ours was gradually struggling. She not only had her troops of industrial chemists; her plant was established and still intact; she had already made all the short cuts to cheap production. And in addition to these circumstances, the fact that the mark is now worth a penny instead of a shilling permits her to sell profitably on the British market at a price below our cost of actual manufacture.

Wanted: A Breathing Space.—Inevitably that means an end to the fine chemical industry amongst us; unless British firms be given a breathing space to prepare for competition on fair terms. Many such firms are at this moment clinging to the hope that the Key Industries Bill which has been promised as the first Government measure of the next session will even yet permit our country to become eventually the source of the world's fine chemical supply. Just as the making of fine chemicals is the complement to the making of dyestuffs, so is this Bill a pendant of the Dyestuffs Act, already approved by an overwhelming majority in the House of Commons.

There does not appear to be any weighty reason why we should send to other countries our coal tar, and other bye-products from the manufacture of dyes, to be made into chemicals by foreign labour in foreign plant erected by foreign capital. The only class amongst us who would benefit would be the handful of brokers who would get their commission out of selling over again such of the bye-products as came back to us in their manufactured state.

The Gain to the Nation.—On the other hand, the national advantages of a flourishing industry such as this will be apparent. Clearly, of course, it would reduce unemployment, add to the taxable income of the country and the rateable value of many cities. Nor need one labour the truism that every fine chemical works may at once in time of war, if unhappily that should ever come, be turned into a munitions factory with skilled chemists and workers complete. They are as necessary to the production of explosives as are steel workers to the production of battleships, and, while both groups of workers may happily never again in our time need to step forward in a national emergency, it is surely essential that they should be there at call, peacefully engaged meanwhile in endeavouring to pay off the National Debt. Indeed, excluding coal mining, the fine chemical industry yields the highest net value of output per head, and it employs the greatest proportion of salaried workers. It offers almost unrivalled scope to those upon whose education nowadays we spend so much. It rounds off that edu cation without any subsidy, training, without cost, research chemists who in turn must add to the national wealth as they open up new paths of enterprise. In short, one may no more set a limit to the future of this industry than to its effect upon sister industries. It it be properly encouraged it will sow prosperity in the most unexpected corners of our whole field of commerce. The chemist is now a mighty ruler and discoverer, and the laboratory harnesses the energies of the earth either to save or to destroy, as the mind of men shall determine.

CHLOROFORM SOLUTIONS OF HYDROGEN CHLORIDE.

By E. J. WILLIAMS.

IN an attempt to prepare a standard solution of hydrogen chloride in chloroform it was found that, on titration with standard alkali, concordant results could not be obtained for successive titrations even when the solutions obtained were largely diluted by the further addition of chloroform.

The solutions were prepared by passing dry hydrogen chloride through dry chloroform purified from methylated chloroform. The minimum concentration of hydrogen chloride present was obtained by running a measured portion of the solution from a burette into excess of standard sodium hydroxide contained in a glass-stoppered bottle, shaking thoroughly, and then running in standard hydrochloric acid to determine the excess of alkali. The chloroform solution could not be measured by a pipette, since the pressure of the hydrogen chloride caused the solution to drip out of the pipette.

The treatment accorded to the solutions and the results obtained are indicated in the subjoined table. All solutions were at laboratory temperature (10° C.).

Method of preparation.	Grams Hydrogen chloride per litre found.
(1) Original chloroform (a)	0·00
(2) Dry hydrogen chloride passed through (1) for half-an-hour (b)	9·50
(3) Solution (2) shaken very slightly and again titrated	7·30
(4) Dry air slowly aspirated through solution (2) for two hours (a)	0·00
(5) 25 cc. of solution (2) diluted to 50 cc. with chloroform (c)	0·68
(6) Solution (5) refluxed for three hours on water-bath (a)	0·00
(7) Dry air slowly aspirated through solution (5) for two hours (a)	0·00
(8) Dry hydrogen chloride passed through (1) for two hours (d)	9·80
(9) 50 cc. of solution (8) diluted to 250 cc. with chloroform (e)	1·60
(10) Solution (8) kept in desiccator over solid caustic soda for 24 hours (a) ...	0·00

(a) Gave no turbidity with silver nitrate.
(b) Liquid fumed strongly in air.
(c) Solution still fumed in air.
(d) Solution fumed strongly in air and repeatedly blew stopper out of bottle while standing.
(e) Fumed strongly.

Summary.

1. Hydrogen chloride can be absorbed by chloroform up to a concentration of about 10 grms. per litre.

2. Equilibrium between solvent and solute is unstable, and unless the solution is kept in a closed vessel the gas passes completely out of solution.

Royal Grammar School Newcastle-on-Tyne.

THE RELATIVE VOLUMES OF THE CHEMICAL ELEMENTS.

By HAWKSWORTH COLLINS.

SINCE it has been proved that it is impossible to compare the relative volumes of substances at their boiling points, but that it is possible to do so at some fixed temperature, 15° C. has been selected in this investigation, because the great majority of specific gravities of substances have been found experimentally at about this temperature.

Whenever the experimental specific gravities of substances have not been given at this temperature, their values have been reduced in a uniform manner in accordance with the experimental data with regard to similar substances.

Since experimentalists very seldom agree to more than three figures in their determination of the specific gravity of a substance, and since it will be seen that the theoretical results nearly always agree with the experimental to three figures, it is evident that the theory is as exact as possible.

The importance of the matter consists in the fact that it throws an entirely new and strong light of mathematical exactitude upon every substance in existence, and ultimately leads to the

demonstration of numerous discoveries concerning Optical Refractivity, Magnetic Rotation, Heat of Combustion, Heat of Formation, &c.

It is necessary to draw special attention to the following statement, which has sometimes been ignored by scientists :—*There is no assumption of any kind whatever in any portion of the following theory.*

The atomic weights of Cl, Br, I, N, H, C, O, S, are taken as 35·5, 79, 127, 14, 1, 12, 16, and 32 respectively.

When it has been definitely proved experimentally that the atomic weights of Cl are 35 and 36, and of Br 79 and 81, the relative volumes of these two elements will have to be recalculated from new experimental data. Meanwhile it is evident that the two volumes of Cl must be very nearly equal, otherwise it would have been impossible to obtain the following results. Similar remarks apply to Br.

When the molecular weight of a substance is divided by the specific gravity, the result is its molecular volume.

The deductions are frequently given before the facts which lead up to them, for the sake of convenience.

First deduction.—*The relative volume of methylene* (CH_2) *at* 15° *C. is* 16·42. The truth of this is apparent by comparing any two of the following compounds which differ by CH_2, or a multiple of CH_2.

Second deduction.—The experimental facts concerning the following 149 molecules demonstrate that the relative volumes at 15° C. of the following atoms or groups are :—

Cl	23·01	CO_2CH_3 ...	49·71
Br	27	$CO_2C_2H_5$ ...	66·13
I	32·75	$CO_2C_3H_7$ ...	82·55
NH_2	16·42	$CO_2C_4H_9$ ...	98·97
CN	23·96	$CO_2C_5H_{11}$	115·39
N_3	32·63	C_6H_5	77·48
NO_2	26·74	C_6H_5	74·45
NO_3	34·27	OH	13·29
SH	25·48	OH	10·21
C_2H_3 ...	41·87	CCl_3	69·74
C_2H_2 ...	28·89	CO.OH ...	23·8
C_2H	31·25		

The relative volumes obtained for the groups C_2H, C_2H_2 and CH_2 may appear to be absurd, but proofs will be given later that they are correct.

There are two values obtained for each of the groups C_6H_5 and OH It would have been much easier to have ignored the two values and to have taken the mean value in each case, but, since we wish to obtain the exact truth and not merely the approximate truth, these apparently contradictory values are purposely introduced at the commencement of the theory.

Name and Chem. Formula.	Vols of Parts.	Theor. S.G.	Observed S.G.
Methylene chloride $Cl—CH_2—Cl$	23·01 — (16·42) — 23·01	1·361	1·378 0° T. ∴ 1·361 15°
Ethylene Cl $Cl—(CH_2)_2—Cl$ ...	23·01 — $(16·42)_2$— 23·01	1·255	1·252 20° B. 1·256 12° Re
Trimethylene Cl $Cl—(CH_2)_3—Cl$ ...	23·01 — $(16·42)_3$— 23·01	1·186	1·189 18° Fr.
Hexylene Cl $Cl—(CH_2)_6—Cl$ ..	23·01 — $(16·42)_6$— 23·01	1·072	1·087 20° C. 1·053 11° H.
5 Methylene bromide $Br—CH_2—Br$	27·00 — (16·42) — 27·00	2·442	2·084 11° St. 2·5 15° P.
Ethylene Br $Br—(CH_2)_2—Br$ . .	27·00 — $(16·42)_2$— 27·00	2·142	2·128 13° D. 2·164 21 Re.
Trimethylene Br $Br—(CH_2)_3—Br$ ...	27·00 — $(16·42)_3$— 27·00	1·937	1·923 Fr. 1.982 15° P.
Hexylene Br $Br—(CH_2)_6—Br$ ...	27·00 — $(16·42)_6$— 27·00	1·587	1°581 19° He. 1·6 13° Be.
Heptylene Br $Br—(CH_2)_7—Br$ ...	27·00 — $(16·42)_7$— 27·00	1·515	1·515 18° T.
10 Ethylene chlorobromide $Cl—(CH_2)_2—Br$ ...	23·01 — $(16·42)_2$— 27·00	1·720	1·705 11°Mo. 1·7 18° H.
Methylene iodide $I—(CH_2)—I$	32·75 — (16·42) — 32·75	3·271	3·285 15° P. 3·23 16° B.
Trimethylene iodide $I—(CH_2)_3—I$	32·75 — $(16·42)_3$— 32·75	2·579	2·576 15° P.
Chloriodomethane $Cl—(CH_2)—I$	23·01 — (16·42) — 32·75	2·445	2·444 14° Sk.
Ethylene chloriodide $Cl—(CH_2)_2—I$	23·01 — $(16·42)_2$— 32·75	2·15	2·151 0° Si.

ABBREVIATIONS.—A, Anschutz; B, Bruhl; Ba, Bauer; Be, Beresty; Bo, Boughton: Br, Brauns; Bt, Berthelot; By, Bruylants; C, Cahours; Ca, Cannizzaro; Car, Carrara; Cl, *Clermont*; C.K., Chemiker Kalendar; Co, Conrad; Ch, Chavanne; Cr Carlet; D, D'Arcet; De, Delffs; Dh, De Heen; Dv, Deville; E, Engler, Er, Erlenmeyer; Ei, Eisenloh; F, Fittig; Fa, Fahlberg; Fd, Friedel; Fh, Fruhling; Fo, Forster; Fr, Freund; G Gladstone; Ga, Gartenmeister; Ge, Gehring; G.T., Garzarolli-Thurnlackh; Gu, Gustavson; H, Henry; Hg, Hodgkins; He, Hecht; Hl, Hell; Ho, Hofmann; I, International Constants; Is, Istrati, K, Kahlbaum; Ke, Kekule; Ko, Kopp; Kr, Krafft; L, Linnemann; Le, Lescher; La, Laurent; Lb, Lieben; Li, Limpricht; M, Mendelejeff; Mo, Montgolfier; J, Jungfleisch; Ma, Malaguti; Mr, Markownikoff; P, Perkin; Pa, Pariselle; Pi, Pickard; Pl, Plimpton; Pt, Paterno; R, Romburgh; Ra, Radziszewski; Rb, Reboul; Re, Regnault; Ru, Rugheimer; S, Schroder; Sa, Saytzeff; Sb Sabanejeff; Sc, Schorlemmer; Sch, Schall; Sh, Schiff; Si, Simpson; Sk, Sakurai; Sl, Silva; Sm, Stohmann; So, Sokoloff; Sr, Schreiner; St, Steiner; Sw, Schwers; T, Thorpe; Tr, Truchot; V, Vogt; Va, Van Nostrand; W, Wurtz We, Werner; Wi, Wiens; Wg, Weger; Wr, Wroblevsky; Z, Zander.

	Name and Chem. Formula.	Vols of Parts.	Theor. S.G.	Observed S.G.
15	Ethylene bromiodide $Br—(CH_2)_2—I$	27·00 — $(16·42)_2$— 32·75	2·527	2·514 30°Fd. 2·7 1° Rb.
	Pentamethylene diamine $NH_2—(CH_2)_5—NH_2$	16·42 — $(16·42)_5$— 16·42	0·887	0·885 15°/4 Va.
	Chloracetonitril $Cl—CH_2—CN$	23·01 — (16·42) — 23·96	1·191	1·193 20° E.
	β-Triazoethylamine $N_3—(CH_2)_2—NH_2$	32·63 — $(16·42)_2$— 16·42	1·050	1·049 16°Fo. ∴ 1·050 15°
	γ-Triazopropylamine $N_3—(CH_2)_3—NH_2$	32·63 — $(16·42)_3$— 16·42	1·017	1·004 25°/4 I. ∴ 1·014 15°
20	Ethylene chloronitrin $Cl—(CH_2)_2—NO_3$	23·01 — $(16·42)_2$— 34·27	1·393	1·378 21° H. ∴ 1·385 15°
	Ethylene dinitrate $NO_3—(CH_2)_2—NO_3$	23·01 — $(16·42)_2$— 34·27	1·500	1·51 4° Va. ∴ 1·50 15°
	Ethylene mecaptan $SH—(CH_2)_2—SH$	25·48 — $(16·42)_2$— 25·48	1·122	1·123 23° We.
	Diallyl $C_2H_3—(CH_2)_2—C_2H_3$	41·87 — $(16·42)_2$— 41·87	0·703	0·707 0° Z. 0·698 12° Sh.

In the following, M stands for methylene (CH_2) both in the formula and in the relative volumes. Its volume is always 16·42.

	Name and Chem. Formula.	Vols of Parts.	Theor. S.G.	Observed S.G.
	Allyl chloride $C_2H_3—M—Cl$	41·87 — M — 23·01	0·941	0·938 20° B. 0·944 15° P.
25	Chloramylene $C_2H_3—M_3—Cl$	41·87 — M_3— 23·01	0·916	0·999 0° Ba. 0·872 5° By.
	Chlorhexylene $C_2H_3—M_4—Cl$	41·87 — M_4— 23·01	0·907	0·904 11° H.
	Allyl bromide $C_2H_3—M—Br$	41·87 — M — 27·00	1·407	1·421 15° P. 1·398 20° B
	Bromhexylene $C_2H_3—M_4—Br$	41·87 — M_4— 27·00	1·204	1·203 15° He
	Allyl iodide $C_2H_3—M—I$	41·87 — M — 32·75	1·845	1·846 15° R. 1·848 12° L.
30	Diallyl hydriodate $C_2H_3—M_4—I$	41·87 — M_4— 32·75	1·497	1·497 0° W.
	Allylamine $C_2H_3—M—NH_2$	41·87 — M — 16·42	0·763	0·769 17°·5 G.
	Dibenzyl $C_6H_5—M_2—C_6H_5$	74·45 — M_2— 74·45	1·001	1·002 14° Li. ∴ 1·001 15°
	Diphenyl methane $C_6H_5—M—C_6H_5$	(77·48 / 74·45) — M — 74·45	1·007	1·006 25°/25 K.
	Diphenyl propane $C_6H_5—M_3—C_6H_5$	(77·48 / 74·45) — M_3— 74·45	0·982	0·996 0° Sl. ∴ 0·983 15°
35	Benzyl chloride $C_6H_5—M—Cl$	74·45 — M — 23·01	1·111	1·113 Ca. 1·103 18° I.
	Benzyl chloride $C_6H_5—M—Cl$	(77·48 / 74·45) — M — 23·01	1·096	1·099 7° G.
	Chlorethylbenzene $C_6H_5—M_2—Cl$	77·48 — M_2— 23·01	1·054	1·068 0° Is. ∴ 1·055 15°
	Benzyl bromide $C_6H_5—M—Br$	74·45 — M — 27·00	1·442	1·438 22° Ke. ∴ 1·445 15°
	Benzyl iodide $C_6H_5—M—I$	(77·48 / 74·45) — M — 32·75	1·742	1·734 25° Lb. ∴ 1·745 15°
40	Benzylamine $C_6H_5—M—NH_2$	74·45 — M — 16·42	0·997	0·990 14° Li.
	Benzylamine $C_6H_5—M—NH_2$	(77·48 / 74·45) — M — 16·42	0·984	0·986 15°/15 Va.
	β-Phenylethylamine $C_6H_5—M_2—NH_2$	77·48 — M_2— 16·42	0·955	0·952 20°/4 I. ∴ 0·955 15°
	β-Phenylethylamine $C_6H_5—M_2—NH_2$	(77·48 / 74·45) — M_2— 16·42	0·966	0·959 25°/25 K. ∴ 0·965 15°
	β-Phenylethylamine $C_6H_5—M_2—NH_2$	74·45 — M_2— 16·42	0·979	0·972 25° I. ∴ 0·979 15°
45	Benzyl cyanide $C_6H_5—M—CN$	74·45 — M — 23·96	1·018	1·015 18° Ho. ∴ 1·018 15°
	Phenylpropionitril $C_6H_5—M_2—CN$	74·45 — M_2— 23·96	1·00	1·0014 18° Ho.
	Ethylene diacetate $CH_3CO_2—M_2—CO_2CH_3$	49·71 — M_2— 49·71	1·104	1·109 14° Sw.

	Name and Chem. Formula.	Vols of Parts.	Theor. S.G.	Observed S.G.
	Propylene diacetate $CH_3CO_2—M_3—CO_2CH_3$	49·71 — M_3— 49·71	1·076	1070 19° Rb. ∴ 1·074 15°
	Methyl suberate $CH_3CO_2—M_6—CO_2CH_3$	49·71 — M_6— 49·71	1·020	1·014 18° La. ∴ 1·017 15°
50	Methyl chloracetate $Cl—M—CO_2CH_3$	23·01 — M — 49·71	1·22	1·22 15° H.
	Ethylene aceto-chloride $Cl—M_2—CO_2CH_3$	23·01 — M_2— 49·71	1·161	1·178 0° Si. ∴ 1·163 15°
	Hexylene aceto-chloride $Cl—M_6—CO_2CH_3$	23·01 — M_6— 49·71	1·042	1·04 6° H.
	Octylene aceto-chloride $Cl—M_8—CO_2CH_3$	23·01 — M_8— 49·71	1·0118	1·011 18° Cl.
	Methyl brombutyrate $Br—M_3—CO_2CH_3$	27·00 — M_3— 49·71	1·43	1·450 5° H. ∴ 1·438 15°
55	Acetoxyacetonitril $CN—M—CO_2CH_3$	23·96 — M — 49·71	1·099	1·100 14° H. ∴ 1·099 15°
	Benzyl acetate $C_6H_5—M—CO_2CH_3$ ...	77·48 — M — 49·71	1·044	1·040 21° G. ∴ 1·045 15°
	Benzyl acetate $C_6H_5—M—CO_2CH_3$ ...	74·45 — M — 49·71	1·067	1·062 15° Va.
	Allyl acetate $C_3H_5—M—CO_2CH_3$ ...	41·87 — M — 49·71	0·9259	0°9258 24°·5 G.
	Ethyl malonate $C_2H_5CO_2—M—CO_2C_2H_5$	66·13 — M — 66·13	1°076	1·068 18° Co. ∴ 1·071 15°
60	Ethylene dipropionate $C_2H_5CO_2—M_2—CO_2C_2H_5$	66·13 — M_2— 66·13	1·054	1·054 15° P.
	Ethyl succinate $C_2H_5CO_2—M_2—CO_2C_2H_5$	66·13 — M_2— 66·13	1°054	1·072 0° Ko. 1·047 26° Ko.
	Ethyl suberate $C_2H_5CO_2—M_6—CO_2C_2H_5$	66·13 — M_6— 66·13	0·997	0·991 15° Hl. 1·003 18° La.
	Ethyl sebate $C_2H_5CO_2—M_8—CO_2C_2H_5$	66·13 — M_8— 66·13	0·979	0·968 15° P. 0·99 25° K.
	Ethyl chloracetate $Cl—M—CO_2C_2H_5$	23·01 — M — 66·13	1·160	1·172 8° H. 1·158 20° B.
65	Et. β chlorpropionate $Cl—M_2—CO_2C_2H_5$	23·01 — M_2— 66·13	1·119	1·116 8° H.
	Et. chlorbutyrate $Cl—M_3—CO_2C_2H_5$	23·01 — M_3— 66·13	1·087	1·052 20° B. 1·122 10° H.
	Et. bromacetate $Br—M—CO_2C_2H_5$	27·00 — M — 66·13	1·515	1·525 18° G. 1·507 25° K
	Et. brombutyrate $Br—M_3—CO_2C_2H_5$	27·00 — M_3— 66·13	1·362	1·363 5° H.
	Et. cyanacetate $CN—M—CO_2C_2H_5$	23·96 — M — 66·13	1·061	1·059 25° K. 1·067 13° H.
70	Et. allylacetate $C_3H_5—M_2—CO_2C_2H_5$ ...	41·87 — M_2— 66·13	0·91	0·922 0° W. ∴ 0·911 15°
	Et allyloctylate $C_3H_5—M_8—CO_2C_2H_5$ ...	41·87 — M_8— 66·13	0·886	0·883 15° P.
	Et oleate $C_3H_5—M_{15}—CO_2C_2H_5$ ...	41·87 — M_{15}— 66·13	0·875	0·875 15° P.
	Methyl ethyl succinate $CH_3—CO_2—M_2—CO_2C_2H_5$	49·71 — M_2— 66·13	1·08	1·092 0° Wg. ∴ 1·08 15°
	Et. phenylacetate $C_6H_5—M—CO_2C_2H_5$ ...	(77·48 / 74·45) — M — 66·13	1·035	1·029 25°/25 K. ∴ 1·035 15°
75	Benzyl propionate $C_6H_5—M—CO_2C_2H_5$ ...	(77·48 / 74·45) — M — 66·13	1·035	1·036 16°·5 Co.
	Et hydrocinnamate $C_6H_5—M_2—CO_2C_2H_5$ ...	(77·48 / 74·45) — M_2— 66·13	1·018	1·012 25°/25 K. ∴ 1·018 15°
	Et. phenpropionate $C_6H_5—M_2—CO_2C_2H_5$ ...	(77·48 / 74·45) — M_2— 66·13	1·018	1·034 0° E. 1·015 20° B.
	Ethylene dibutyrate $C_3H_7—CO_2—M_2—CO_2C_3H_7$	82·55 — M_2— 82·55	1·021	1·024 0° W.
	Ethylene butyro-chloride $Cl—M_2—CO_2C_3H_7$	23·01 — M_2— 82·55	1·087	1·085 0° Si.
80	Pr. phenylacetate $C_6H_5—M—CO_2C_3H_7$ ...	(77·48 / 74·45) — M — 82·55	1·017	1·014 18° Hd. ∴ 1·017 15°
	Benzyl butyrate $C_6H_5—M—CO_2C_3H_7$ ...	(77·48 / 74·45) — M — 82·55	1·017	1·016 16° Co. ∴ 1·017 15°

No.	Name and Chem. Formula.	Vols of Parts.	Theor. S.G.	Observed S.G.
	Pr. phenpropionate C_6H_5—M_2—$CO_2C_3H_7$ ...	(77·48 / 74·45)— M_2— 82·55	1·003	1·015 0° Wg ∴ 1·002 15°
	Butyl chloracetate Cl—M —$CO_2C_4H_9$	23·01 — M — 98·97	1·087	1·081 15° Ge.
	Chlorethyl alcohol Cl—M_2—OH	23·01 — M_2— 10·21	1·219	1·201 19° Va.
85	Trimethylene chlorhydrin Cl—M_3—OH	23·01 — M_3— 10·21	1·146	1·132 17° Tr.
	Octylene chlorhydrin Cl—M_8—OH	23·01 — M_8— 10·21	0·999	0·987 31° Cl. ∴ 0·999 15°
	Ethylene cyanhydrin CN—M_2—OH	23·96 — M_2— 10·21	1·059	1·059 0° E.
	Butylene-1-ol-4 C_2H_3—M_2—OH	41·87 — M_2— 10·21	0·848	0·848 17°/0 Pa.
	Benzyl alcohol C_6H_5—M —OH	(77·48 / 74·45)— M — 10·21	1·053	1·051 15° Ko. 1·059 Ca.
90	Phenylethyl alcohol C_6H_5—M_2—OH	74·45 — M_2— 10·21	1·038	1·034 21° C.K. ∴ 1·038 15°
	Benzyl carbinol C_6H_5—M_2—OH	74·45 — M_2— 10·21	1·038	1·034 21° Ra. ∴ 1·038 15°
	Benzyl carbinol C_6H_5—M_2—OH	(77·48 / 74·45) — M — 10·21	1·025	1·024 15° Va.
	Phenylpropyl alcohol C_6H_5—M_3—OH	74·45 — M — 10·21	1·015	1·008 20° B. ∴ 1·013 15°
	Phenylbutanol C_6H_5—M_4—OH	77·48 — M_4— 10·21	0·978	0·976 17°/4 I. ∴ 0·978 15°
95	Propyl glycollate $C_3H_7CO_2$—M— OH ...	82·55 — M — 10·21	1·081	1·084 Sr.
	Hexylene chlorhydrin HO—M_6—Cl	13·29 — M_6— 23·01	1·012	1·018 11° H. ∴ 1·012 15°
	Trimethylene bromhydrin HO—M_3—Br	13·29 — M_3— 27·00	1·541	1·537 20° Fh. 1·543 15°
	Hexylene bromhydrin HO—M_6—Br	13·29 — M_6— 27·00	1·297	1·296 11° H.
	Ethylene monoacetate HO—M_2—CO_2CH_3	13·29 — M_2— 49·71	1·085	1·0+ Va.
100	Et. glycollate HO—M —$CO_2C_2H_5$ ...	13·29 — M — 66·13	1·085	1·083 23° Va. 1·107 Sr.
	Glycol HO—M_2—OH	13·29 — M_2— 10·21	1·101	1·125 0° Va. ∴ 1·111 15°
	Trimethylene glycol HO—M_3—OH	13·29 — M_3— 10·21	1·045	1·062 0° Z. ∴ 1·048 15°
	Dipropargyl C_2H—M_2—C_2H	31·25 — M_2— 31·25	0·818	0·81 18° H. 0·82 Bt.
	Propargyl chloride C_2H—M —Cl	31·25 — M — 23·01	1·054	1·045 5° H.
105	Propargyl bromide C_2H—M —Br	31·25 — M — 27·00	1·58	1·59 11° H. ∴ 1·58 15°
	Propargyl acetate C_2H—M —CO_2CH_3	31·25 — M — 49·71	1·007	1·005 20° B. 1·003 12° H.
	Propargyl alcohol C_2H—M —OH	31·25 — M — 10·21	0·967	0·963 21° H. ∴ 0·967 15°
	Phenylnitromethane C_6H_5—M —NO_2	74·45 — M — 26·74	1·165	1·160 20°/4 I. ∴ 1·165 15°
	Sebacic acid CO_2H—M_8—CO_2H	23·80 — M_8— 23·80	1·13	1·132 Cr.
110	Brassidic acid C_2H_3—M_{19}—CO_2H	41·87 —M_{19}— 23·80	0·895	0·858 57°/4 Va. ∴ 0·89 15°
	Hexachlorpropane CCl_3—M —CCl_3	69·74 — M — 69·74	1·61	1·626 C.
	Tetrachlorethane CCl_3—M —Cl	69·74 — M — 23·01	1·539	1·530 17° Re 1·576 19° Re
	Brommethylchloroform CCl_3—M —Br	69·74 — M — 27·00	1·869	1·884 0° H. ∴ 1·863 15°
	Trichlorethyl acetate CCl_3—M —CO_2CH_3 ...	69·74 — M — 49·71	1·409	1·391 23° G T. ∴ 1·40 15°
115	Trichlorethyl alcohol CCl_3—M —OH	69·74 — M — 10·21	1·551	1·55 20°·3 G.T.

(To be continued.)

THE VALUE OF SCIENTIFIC RESEARCH.*

The Wheat Pests Problem.

It is now well recognised that scientific research is of great money value, but it is not often that successful practical results follow so quickly upon research as in the recent campaign against the insect pests in the vast quantities of wheat which, owing to the war, accumulated in Australia. In this campaign, South Australia played a very important part. In the early stages of the weevil plague, at the instance of Mr. G. G. Nichols, Manager of the South Australian Wheat Scheme, a Wheat Weevil Committee was appointed, consisting of Dr. W. A. Hargreaves, Director of the South Australian Department of Chemistry (Chairman), Mr. G. G. Nicholls, Mr. W. J. Spafford (Superintendent of Experimental Work, Department of Agriculture), Mr. A. M. Lea (Emtomologist to the S.A. Museum), Mr. E. A. Badcock (Manager, S.A. Farmers' Co-operative Union, Ltd.), and Mr. J. T. Jackett (Miller). Subsequently Mr. D. C. Winterbottom (Supervisor of Weevil Department in S. A. Wheat Scheme) was added to the Committee. The work of scientific research on the subject was taken up by the Department of Chemistry, and from experiments conducted in the laboratory of that Department three practical systems of treatment were devised. These, when put into use by the Wheat Boards in the States of South Australia, Victoria, and Western Australia, resulted in saving wheat worth at least £1,500,000, besides giving very valuable knowledge on the whole problem of stored wheat which will be of service in the future. This estimate of monetary value is an approximation. It is, however, based on the observation that the actual weevil damage was at least reduced to one-half of what it would otherwise have been. Senator Russell, Chairman of the Australian Wheat Board announced on January 10 of this year that the actual weevil damage done to the wheat purchased by the British Government during the time it was held after purchase and before shipment had been assessed at 2,200,000 bushels, and that the British Government had agreed to pay the Australian Wheat Board the sum of £552,000 to cover this loss. This was based on the contract rate of 4s. 9d. per bushel. The amount paid for losses can be taken as a low estimate of the value of the wheat saved for the British Government. During the three years 1915-16, 1916-17, 1917-18, the Commonwealth production of wheat was 404,000,000 bushels, of which South Australia contributed 98,000,000, and Victoria 136,000,000 bushels. The British Government contract was for 112,000,000 bushels, of which South Australia supplied 36,000,000, and Victoria 40,000,000 bushels, so that in round figures the British Government took about one-quarter of the Commonwealth output, and this entailed about one-third of the output of South Australia and Victoria. The savings to each of the States of South Australia and Victoria can be taken then to be at least an equal amount to that saved for the British Government. Hence we arrive at the conservative estimate of £1,500,000 worth of wheat saved from destruction as the result of scientific research. The following figures may help to demonstrate the extent of the undertaking as it affected South Australia, where the wheat had to be safeguarded from mice, weevils, etc. The crop carried over from 1917-18 and in stacks was 42,000,000 bushels. The 1918 crop was 26,000,000 bushels, making a total of 68,000,000 bushels on hand. During the twelve months following only about 11,000,000 bushels were disposed of, leaving nearly 57,000,000 bushels to be carried over to 1918-19. The 1919 crop was over 20,000,000 bushels, and left no less than 77,000,000 bushels to be guarded. Some idea of the magnitude of the work can also be gained from the following remarks made by Mr. R. A. Love, who was the Australian Commissioner for the Royal Commission of Food Supplies in London: "The cleaning, sterilising, and handling that had to be undertaken in Australia in connection with the wheat was without doubt the largest campaign of its sort that the world has ever had to undertake. When one considers the enormous amount of labour and the handling involved to enable the vast quantities to be cleaned, sterilised, and made fit for shipment, it was truly colossal In looking back over the work, I think we can be proud of the results of our labours. It is nice to feel, considering the enormous amount of thought and worry put into the task, that it was successful in results, efficiency, and cost. The gassing campaign without doubt saved an enormous amount of money, and enabled vast quantities of wheat to be held over until they could be treated." The methods recommended by the Wheat Weevil Committee as the result of the scientific research carried out by the Department of Chemistry were the following.

1. *Cleanliness.*—The weevil was recognised as a pest which was fostered by careless and dirty conditions. Cleanliness in the collection, transport, and storage of the wheat was therefore advocated. In storage, the chief problem was to prevent contamination of the stacks from without. Hence the following precautions were enjoined: absolutely clean stacking sites, impervious insect-proof floors, thorough cleaning up of old stacking sites, and gutters filled with water, oil, or molasses, placed around the base of the stacks to prevent access of crawling weevils. Stacks were either enclosed in hessian and then limewashed, or wherever practicable, entirely enclosed in mathoid sheds. The malthoid sheds, first tried at the suggestion of Mr. A. M. Lea, a member of the Wheat Weevil Committee, proved the most successful.

2. *Gas Treatment.*—The use of poison gas for the extermination of vermin is by no means a new idea, and as far back as 1890, gas plants were used in South Australia for the purpose of suffocating rabbits in their burrows by means of air deprived of its free oxygen by being passed through a fire. During the mouse plague of 1916-17, Dr. Hargreaves had suggested the use of a gas producer plant for providing large quantities of cheap gas for the extermination of mice, and in the middle of 1917, Mr. Saunders, of Clutterbuck Bros., of Adelaide, experimented with producer gas as a means of destroying weevils, but these initial experiments were unsatisfactory because the treatment was not continued nearly long enough. Carbon dioxide compressed in cylinders had been advocated in 1898 by Noel Paton, and

*From "Report No. 2 of the State Advisory Council of Science and Industry of South Australia."

in 1911, 1912, and 1913, by Barnes and Grove, but their methods were prohibitive on account of cost. It was not until the time factor was shown to be an important one, by experiments with weevils in closed bottles, carried out in January, 1918, by Mr. Spafford, a member of the Committee, that gas treatment was found effective. Mr. D. C. Winterbottom, chemist in the Department of Chemistry, was transferred to the South Australian Wheat Scheme, as officer supervising weevil destruction, and he installed the first gas plant in Australia. It was a decided success. Subsequently other plants were installed by him in South Australia and Victoria, and similar plants were used in Western Australia. The operation of these gas plants in South Australia was placed in the hands of Messrs. S. D. Shield and E. A. Pengelly, research chemists of the Department of Chemistry, and in Victoria the plants were in charge of Mr. P. J. Thompson, of the Melbourne University. The method employed was as follows. The stacked grain was entirely enclosed in sheds covered with malthoid or similar material made as nearly air-tight as possible. Then air freed from free oxygen by being passed through a furnace similar to that of a gas producer, but producing carbon dioxide instead of carbon monoxide, was blown into the shed for three or four weeks to asphyxiate the insects. Many large stacks were thus successfully treated. In one case the stack contained 200,000 bags of wheat.

3. *Heat Treatment.*—In the cleaning and shipment of the weevilly wheat, heat treatment to a temperature of 140° or 150° Fahrenheit was found to be the most effective method of checking further outbreak of weevil. Soon after research was commenced in August, 1917, Mr. Winterbottom found that this would probably be a successful method, and experiments were made to see the effects of heat treatment on the wheat. It was proved that the flour and bread-making properties were not impaired. A machine was invented in the Department of Chemistry and erected at Port Adelaide, which killed all the insects passed through it without damaging the wheat. This was the first successful heat treatment plant in Australia. Professor Lefroy was working on behalf of the British Commission in Sydney, and he investigated a large number of devices for destroying weevils, including a number of heat treatment machines designed by different inventors. He finally adopted the Poole and Steele machine. At first this machine was not successful, but Dr. Hargreaves was able, as a result of experience gained by the research experiments, to suggest at a conference in Sydney in March, 1918, certain modifications which resulted in the successful working of the machine, which was then adopted by the British Commission. The effects of this successful end to the investigations will be more far-reaching than they appear at first sight. Not only can the saving of the wheat stored during the war, which would otherwise have been destroyed by insect pests, be directly credited to scientific research, but the results obtained have demonstrated the practical value of the methods used. These methods can be used in future, so that the total money value of the research is beyond assessment.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, January 27, 1921.

Prof. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read :—

"*The Myogram of the Flexor-reflex Evoked by a Single Break-shock.*" By K. SASSA and Prof. C. S. SHERRINGTON.

In the spinal preparation a single break-shock applied to an afferent nerve or to local skin evokes, when the shock is considerably above threshold value, a reflex contraction which is both stronger and more prolonged than is the maximal twitch evoked from the motor nerve itself. This is so, whether or no the muscle retains its intrinsic proprioceptive reflex arc. This excess of the reflex contraction over maximal twitch indicates that summation of successive contraction-waves is present in the former. Repetitive discharge from the reflex centre occurs therefore in response to a stimulus consisting of a single induction shock. The reflex repetitive response is more ample, strong, and prolonged in the spinal condition than in the decerebrate.

"*'Intertraction' between Albuminous Substances and Saline Solutions.*" By Sir ALMROTH WRIGHT.

The paper takes, as its point of departure, the observation that the introduction of 5 per cent salt solutions into wounds is followed by an abundant outflow of albuminous fluid. There is thus provided an agency—an agency largely employed in the war in the treatment of foul wounds—by which corrupted discharges lodged in recesses of a wound can be evacuated and then replaced by uncorrupted fluid drawn from the blood.

It is demonstrated in this paper by means of experiments in which serum is directly superimposed upon heavier salt solutions, and corresponding experiments in which lighter salt solutions are superimposed upon heavier serum, that the fluids thus brought into conjunction interpenetrate with extreme rapidity—the lighter fluid being carried down into the heavier subjacent fluid, while at the same time the heavier fluid is carried up into the superjacent stratum.

The mechanism of this is described and discussed, and it is shown that the phenomena are due to an interaction between the salts and the albuminous substances. The designation "intertraction" is applied to this form of interaction; and it is suggested that these forces supplement diffusion and are an important agency in bringing about interfusion.

In supplementary experiments it is shown that by the aid of the intertraction here in question microbes lodged in serum are rapidly carried down into heavier, or caught up into lighter, salt solutions.

"*Local and Generalised Action of Radium and X-rays upon Tumour Growth.*" By S. RUSS, D.Sc., HELEN CHAMBERS, M.D., and GLADWYS M. SCOTT.

The attempt has been made to find the effects of the beta and gamma rays from radium and

X-rays upon rat tumours, under varying conditions. The local effects were obtained by exposing the tumour only to measured quantities of radiation, the animal not sharing, to an appreciable extent, in the irradiation.

When large doses are employed, destructive action upon the tumour cells is observed; as the dose is reduced, the action tends to become stimulative in character, so that the tumour cells grow more rapidly than they would, had they received no radiation.

The generalised effects of the rays used were obtained by submitting the whole animal to the radiation, the tumour in the animal being screened by the use of suitable screens. It was found that large generalised doses could not be borne by the animals; when, however, they were given repeated small doses, an increase in body weight and an increase in resistance towards tumour growth was observed.

Under the usual conditions of radiation treatment in malignant disease in man, the body shares to some extent in the radiation administered to the tumour, and the bearing of the present observations in this connection is discussed.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences.

Vol. clxxi., No. 19. November 8, 1920.

CATALYTIC DEHYDRATION OF AMYLIC ALCOHOL OF FERMENTATION.—M. J. B. Senderens.—It is generally known that amyl alcohol, which boils between 129° and 132° is a mixture of isopropylethyl alcohol and methylethylethyl alcohol. These alcohols dehydrate in the presence of zinc chloride, which is represented by the following accepted equations:—

(a) $\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right\rangle CH \cdot CH_2 \cdot CH_2OH =$

Isopropylethyl alcohol

$\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right\rangle CH \cdot CH : CN_2 + N_2O$

Isopropylethylene

(b) $\left.\begin{matrix}CH_3 . CH_2\\CH_3\end{matrix}\right\rangle CH \cdot CN_2OH =$

Methylethylethyl alcohol

$\left.\begin{matrix}CH_3 \cdot CH_2\\CH_3\end{matrix}\right\rangle C : CH_2 + N_2O$

methylethylethylene

In reality the principal product of dehydration of amylic alcohol of fermentation by zinc chloride is trimethylethylene $\left(\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right\rangle C : CH \cdot CH_3\right)$. According to Wischnegradsky this dehydration should furnish 50 per cent of trimethylethylene, soluble in dilute sulphuric acid (2 vol. of strong acid+1 vol. of water) the insoluble portion consisting of isomeric amylenes and amylene hydrides (*Comptes Rendus*, 1878, lxxxvi., 973; *Bull. Soc. Chim.*, 1877, i., 261 and 452; 1892, ii., 1340). It is the hydrolysis of this sulphuric acid solution of trimethylethylene which gives the hydrate of amylene $\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right\rangle COH.CH_2.CH_3$ and tertiary amyl alcohol.

Vol. clxxi., No. 20. November 15, 1920.

MICROCHEMICAL REACTIONS OF SODIC ACID.—M. A. Bolland—The following reactions have been obtained using an aqueous solution of solid iodic acid. (1) With thallium nitrate. In the first instance, needles are formed which unite into crosses, simple, double, and multiple. The microscopic appearance is in general similar to the iodide of palladoammonium. Their mean length is about 40 μ. The best strength of solution to use in order to obtain the precipitation is 1 : 5000 (iodic acid : water). (2) With silver nitrate. The product of the reaction is amorphous. It dissolves in ammonia; after evaporating off the ammonia, rhombic plates are obtained, similar to those of manganese oxalate. Strength of solution, 1 : 5000. (3) With barium chloride. Barium chloride precipitates needles. Their length being up to 300 μ. Strength of solution, 1 : 2500. (4) With Strontium Acetate. Needles and thin prisms are obtained, their length reaching to 100 μ. Strength of solution, 1 : 300. (5) With calcium acetate. Colourless octahedra are obtained, whose extinction between crossed Nicols show that they belong to the monoclinic system. Mean length, 150 μ. Strength of solution, 1 : 300. The author has experimented with many other reagents, including rubidium chloride, ammonia, &c., the results of which he gives in the above paper.

NOTES.

TOXICITY OF BARIUM CARBONATE TO RATS.—A series of experiments on the toxicity of various substances to rats and their suitablity for poisoning these animals was undertaken by the U.S. Bureau of Chemistry as part of the rat-extermination work of the Department of Agriculture. The results of the tests with barium compounds brought out the following facts. *Lethal Dose for* Rats.—Barium chloride, subcutaneously, 45 to 89 mgrms. per kilo., by stomach tube, 350 to 535 mgrms. per kilo; barium carbonate, per os, 630 to 750 mgrms. per kilo. On the basis of the barium content, the carbonate is about two-thirds as active as the chloride when administered per os. The average intake of food, both poisoned and unpoisoned, by hungry white rats, was one-hundredth of their body weight. 20 per cent of barium carbonate in the rat bait was found to be an efficient concentration. With this percentage a rat is required to eat only one-third or three-eighths of a meal of average size, or 1/320 to 1/266 of its own weight, in order to secure the ingestion of a lethal amount. With this concentration, many of the rats die within the first 24 hours, the chief factor being the consumption of an amount larger than the minimum efficient lethal dose.—*Journal of the Franklin Institute*, January, 1921.

THE USE OF AMMONIUM PERSULPHATE FOR REVEALING THE MACROSTRUCTURE OF IRON AND STEEL (U.S. Bureau of Standards, Scientific Paper No. 402).—Ammonium persulphate is a widely used etching reagent for copper alloys, but the advantages of its use with iron and steel have been almost entirely overlooked. The article describes the method of application of the reagent and gives photographs to illustrate typical results obtained. Ammonium persulphate decomposes upon the ad-

dition of water, so that the action of the reagent is that of a weak acid intensified by the presence of oxygen. Chemical unhomogeneity is readily shown by the reagent, but the most characteristic feature in its action is the readiness with which it reveals the crystalline condition of the material —*Journal of the Franklin Institute*, January, 1921.

"100 PER CENT." *Daily Mail* EFFICIENCY EXHIBITION.—From February 10 to February 26 the *Daily Mail* Efficiency Exhibition will be open at Olympia. Its scope and interest may be measured from the following summary of its main sections Scientific—Research, Invention, Motion Study, Chemistry &c. Industrial—Factory planning, Equipment and Plant, Waste Elimination, Employees' Welfare, &c. Commercial—Organisation, Distribution, Printing, Advertising, Costing, Office Equipment, Insurance, &c. Civic and National—Education, Physique, Traffic, Transport, &c. Personal—Technical and Professional Colleges, Mind Training, Vocational Guidance, Languages, &c. An important exhibit will be that illustrating the work of the Ministry of Labour's Industrial Training Department. This Department is responsible for the intensive training of ex-Service men in skilled trades, and the whole of the Olympia Annexe will be devoted to showing how the ex-fighting man is quickly trained to help the nation win in the great Industrial World-War. The Efficiency Exhibition and the lessons to be learned there promise to mark the beginning of a new era for the British man of business, whatever industry or calling he may be associated with. It will be responsible for much "scrapping" of machinery, methods, and buildings. A period of trade depression and low output is the very moment when important reconstruction work can be undetaken. The present slack time offers golden opportunities to those with foresight and imagination, and the *Dail Mail's* Efficiency Exhibition comes at an extraordinarily opportune moment. We are no longer too busy to think, and Olympia in February will *make* us think.

ROYAL INSTITUTION.—A General Meeting of the members was held on the 7th inst., Sir James Crichton-Browne, Treasurer and Vice-President in the Chair. Mr. J. McIlwaine Cater, Mr. C. C. Paterson, and Mr. C. Western were elected members. On Saturday, February 12, at 3 o'clock, Prof. A. Fowler begins a course of three lectures at the Royal Institution on "Spectroscopy." The Friday evening discourse on February 11 will be delivered by Dr. F. W. Aston on "Isotopes and Atomic Weights," and on February 18 by Mr. Solomon J. Solomon on "Strategic Camouflage."

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

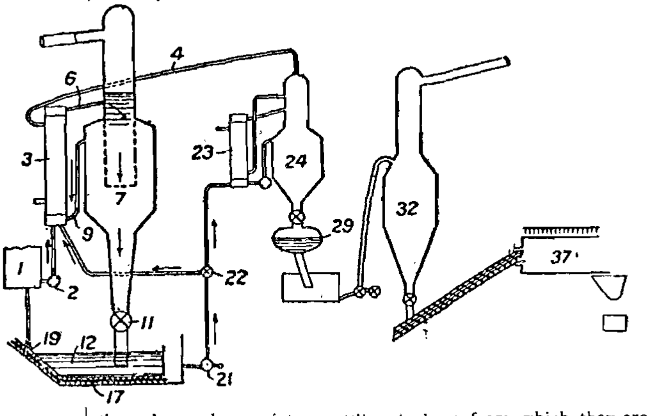
2068—Ashcroft, E. A.—Metallurgy of lead and zinc and their sulphides. Jan. 14th.
1172—Barron, E. C.—Chemical fire-extinguishers. Jan. 10th.
1447—Brat, P.—Recovering nitrogen in the form of ammonia from peat. Jan. 10th.
1911—Clavel, R.—Treatment of cellulose acetate or products made therewith. Jan. 12th.
1690—Foster, J.—Method of producing lime for building together with ammonia and a gas for power purposes. Jan. 11th.
1191—Helbronner A.—Manufacture of sulphuric acid. Jan 10th.
1415—Hilpert, S.—Treatment of waste sulphuric acid. Jan. 10th.
1946—Hodge, J.—Sulphuric-acid valves. Jan 13th.
1687—Wailin, E.—Production of steinholz from magnesia and magnesium salts. Jan 10th.
2693—Bader, W.—Manufacture of pyrosulphates. Jan. 20th. British Cellulose & Chemical Manufacturing Co., Ltd.
2554—Conover, C.—Purification of naphtalene. Jan. 19th.
2224—Delaroziere, F. F.—Manufacture of sodium and potassium ferro-cyanide. Jan. 17th.
2275—Kestner, P.—Metallic media for fixation of oxygen of water in appartus for abstracting gases from liquids. Jan. 17th.
2589—Lunden, H. L. R.—Production of nitrogen compounds by absorption of nitrogen in a mixture of reaction. Jan. 19th.
2914—Lunden, H. L. R.—Preparation of a mixture of compounds of alkaline earth metals and carbon for absorption of nitrogen. Jan. 22nd.
2281—Pearson, A.—Manufacture of zinc oxide. Jan. 17th.
2411—Wargons Aktieholag—Method of producing cyanamide from calcium cyanamide. Jan. 18th

Specifications.

156269—Steel, B. D. and Robertson, R. B.—Method of conducting fusions with molten caustic soda or caustic potash.
152975—Toniolo, C. and Officine Elettrochimiche Dottor Rossi—Processes for the production of hydrogen and mixtures hydrogen and nitrogen.
145511—Badische Anilin and Soda-Fabrik—Manufacture and production of solutions of cellulose acetates.
147099—*Still, C.*—Method of treating crude gas liquor to obtain ammonia solution.
156831—Gee, J. E.—Thermostats.
156892—Wade, H. Manufacture of insoluble of thorium compounds
156896—Howse, G. H.—Solutions of phenol-alde-hyde condensation products.
156916—Manufacture of acetic acid.

Abstracts.

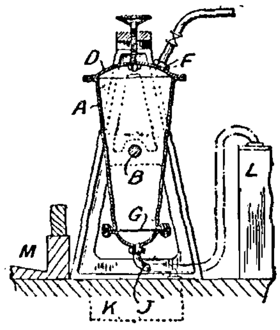
Mr. J. B. Hobsbawn of Hove, has obtained a Patent No. 153649 or a new method of obtaining Sodium Nitrate from its solutions. First separate a considerable proportion of the sulphates and chlorides present by concentration under an absolute pressure of 11lb. per square inch until the temperature of 90-95° C, is reached and afterwards concentrating the liquor at atmospheric or other pressure until the content of chloride (calculated as the sodium salt) is 75-80 grams. per litre. The concentrated liquor is then cooled for the production of sodium nitrate crystals. The first stage of the concentration is effected in a vacuum evaporator, consisting of a heater 3 and a separator 7 connected by circulating pipes 6, 9. The crystals of chlorides and sulphates that separate are discharged



through a valve 11 into a settling tank 12 from which they are removed by conveyors 17, 19. The crystals may be washed by liquor from the store tank 1. A pump 2 feeds liquor from the store tank 1 to the heater 3, and a pump 21 returns the liquor from the settling tank 12 to the heater. The second stage of the concentration is effected in an intermittently working evaporator consisting of a heater 23 and a separator 24 operating under a pressure such that the steam generated may be led by a pipe 4 to the heater 3 and

used as a heating-agent therein. The evaporator 23, 24 is filled by adjusting a valve 22 so as to permit a portion of the liquor from the pump 21 to enter the heater 23. When the liquor has reached the prescribed concentration the contents of the evaporator 23, 24 are discharged through a filter 29 and are pumped into a chamber 32 maintained under an absolute pressure of 12-13lb. per square inch, and are cooled to 70-75° C by evaporation under the reduced pressure. The liquor is then transferred to a rotary cooler 37, in which the sodium nitrate separates.

Ammonium Sulphates.—A new process for treating Ammonium Sulphates is the subject of a Patent No. 154328 by Mr. N. Wilton of 100, Station Road, Hendon. To remove mother liquor from wet sulphate of ammonia the crystals are placed on a perforated plate G within a vessel A provided with a cover D, and dry steam or steam and air is blown in from the top by pipe F in order to drive the liquid out by a pipe J to the saturator L or to the tank K. Ammonia may be introduced at any stage to neutralise remaining acid. The vessel A, which may be steam jacketed and made of acid resisting material, is mounted on trunnions B to allow of the dried crystals being tipped out into the storage chamber M.



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MEETINGS FOR THE WEEK.

Monday, February 14.

Royal Society of Arts, 8. (Cantor Lectures). "Applications of Catalysis to Industrial Chemistry," by Dr. Eric K. Rideal.
Institution of Electrical Engineers, 7. Discussion on Design of a Large Power Station." Also Meeting at Newcastle, 7 15—"Temperature Units of Large Alternators," by G A Juh in.
Biochemical Society.

Tuesday, February 15.

Royal Institution, 3. "The British Soldier since the Restoration—His Unmilitary Services," by Hon. J. W Fortescue.
Society of Chemical Industry, (At Edinburgh).
Institution of Petroleum Technologists, 5 30.

Wednesday, February 16.

Royal Society of Arts, 4.30.
Royal Microscopical Society, 8.

Thursday, February 17.

Royal Institution, 3. "Oceanography—The Sea Fisheries" by W. A. Herdman.
Institution of Electrical Engineers, 6. "Feebly Magnetic Materials" I—"Instrumentation" by Prof. E. Wilson.
Institution of Mining and Metallurgy, 5.30.
Chemical Society, 8.
Royal Society. "A Comparison of Magnetic Declination Changes at British Observatories," by Dr. C. Chree. "The Transmission of Electric Waves round the Earth's Surface," by Prof. H. M. Macdonald. "The Stability of Fluid Motion," by Prof. T. H. Havelock. "On the Transformation of Integrals," by Prof. W. H. Young. "The Constitution of the Alloys of Aluminium, Copper and Zinc, containing High Percentages of Zinc," by J. L. Haughton and Kathleen E. Bingham.

Friday, February 18.

Royal Institution, 9. "Strategic Camouflage," by Solomon J. Solomon.
Royal Society of Arts, 4.30.
Institute of Metals, 7.30. (At Sheffield).

Saturday, February 19.

Royal Institution, 3. "Spectroscopy—Regularity in Spectra," by A. Fowler.

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THE UTILISATION OF BASIC SLAG.

By E. J. RUSSELL, D Sc., F.R.S., Director of the Rothamsted Experimental Station.

THE utilisation of basic slag in agriculture is one of those important developments in agricultural science for which the credit is due in the first instance to British investigators. The possiblity of utilising basic slag was put to practical test by the late John Wrightson at Ferryhill and at Downton in 1884 and 1885, and, in spite of some opposition on theoretical grounds by other workers, a good case was made out. The first field experiments were carried out in the south of England, but the centre of interest soon shifted to the north, and the most striking tests were carried out at Cockle Park, under the direction successively of Prof. Somerville, Sir. T. H. Middleton, and Prof. Gilchrist. To these three more than any others we owe the great advances in knowledge of the use of basic slag.

The standard experiments and the well-known trials were all made with the Bessemer slag. If agriculturists could have been assured of a steady supply of, say, 300,000 or 400,000 tons per annum of high-grade Bessemer slag containing some 20 per cent of P_2O_5, there would have been no need for this discussion; the problem would have been the purely academic one of working out the constitution of the effective constituents of the slag.

The introduction of the basic open hearth process, however, has threatened the supersession of the Bessemer process, and agriculturists can no longer feel certain of receiving adequate supplies of slag of the type to which the old material belonged. Three distinct substances are now used under the one name of basic slag :—

(1) Bessemer slag, containing about 20 per cent P_2O_5 (43·6 per cent tricalcic phosphate).
(2) Open hearth basic slag, 7 to 14 per cent P_2O_5 (15·4 to 31 per cent tricalcic phosphate).
(3) Open hearth basic slag, 7 to 10 per cent P_2O_5 (15·4 to 21·8 per cent tricalcic phosphate), in the manufacture of which a considerable proportion of calcium fluoride has been used.

The phosphorus of the first two types of slag is nearly all soluble (85 per cent or more) in 2 per cent citric acid under certain conventional conditions : that of the third type is not—only 20 per cent or less dissolving.

It may be said at once that no important agricultural distinction between the first and second of these classes has been proved with certainty when the slags are used in quantities containing equal amounts of phosphorus, and so far as present information goes, these slags are of equal value per unit of phosphorus to agriculturists. There are, of course, disadvantages in low-grade materials, in that large bulks have to be handled, and therefore larger expenditure is incurred, and deliveries to the form or field may be delayed. But when allowance has been made for these items, there is no great difference between the two classes of slag. The third class, however, is somewhat different, and agricultural investigators generally agree that it is less effective than the first two types, though they have not yet wholly succeeded in evaluating it.

Broadly speaking, the problem resolves itself into three broad divisions :—

(1) What is the agricultural value of the various basic slags likely to be available in the near future?
(2) Is this value related to the chemical constitution of the slag in any simple way that would allow of some chemical expression and on which an evaluation method might be based?
(3) Is it possible for the steel works to increase the phosphorus content of the slag and generally to increase the effectiveness of the so-called low-grade slags?

The determination of agricultural value requires in general two distinct types of experiments —pot experiments and field trials. Pot experiments are more accurate than field trials, being much more under control : results can be obtained in a single season which are reliable within about 5 per cent. On the other hand, the rigid control of the conditions introduces a large element of artificiality, so that the results are never final. In the writer's experience, a positive result in pot experiments is not always paralleled by a positive result in the field, as some nullifying factor may come into operation; on the other hand, a negative result in pot experiments is usually associated with a negative result in the field.

Although the pot experiment gives useful information, the field experiment has always to be made before any idea can be formed as to the economic importance of the factor under investigation. It is necessary also that the field trial should be repeated on different types of soil and in different climatic conditions. Fortunately, an organisation of agricultural investigators—the Agricultural Education Association—covers Great Britain, and enables co-operative trials to be made. An extended trial of the three types of basic slag is now being organised which should give much valuable information.

The difficulty of studying this particular problem in the past has been to obtain basic slag of known history. In one or two instances a long, laborious agricultural investigation has been deprived of much of its value because the slag supplied for the purpose was not what had been promised.

Field experiments when well carried out are liable to an error of about 10 per cent. Farmers' trials are less reliable : the error may be anything from 20 to 100 per cent , or even more.

Provided the supply of basic slag of known origin can be assured, the agricultural trials can be carried out by the sub-committee of the Agricultural Educational Association, which has been set up for this purpose.*

So much for the method of investigation. We must now consider some of the general results. The old Bessemer slag has proved in the farmers' experience extraordinarily valuable for the improvement of heavy grassland; no single fertiliser has been anything like as effective for this particular purpose. The effect is mainly indirect, and is traceable to the remarkable development

of white clover which follows the application of the slag. It is not yet ascertained whether this effect is due to direct action of phosphates on the plant, or whether the slag in some way is helpful to the micro-organisms associated with the clover root.

Whatever the cause, the result of this spread of white clover is to increase the stock of nitrogen in the soil, and add greatly to the soil fertility. Further, it adds considerably to the value of the herbage, clover being one of the best of the green foods available. Another factor also contributes to the nutritive effect; additions of phosphate to the soil tend to add to the phosphorus content of the crop, and this in turn raises its feeding value.

The use of Bessemer basic slag has not been restricted, however, to grassland. It has proved effective in increasing yields of crops on arable land, particularly in the West and North. So far as the evidence goes, the feeding value of the crop is also increased, though the experiments are not very numerous.

As already stated, the open hearth basic slag made without fluorspar has hitherto proved practically as effective as the old Bessemer slag when compared on the basis of equal amounts of phosphorus. The fluorspar slag, has, however, proved distinctly less effective in pot experiments and in Oldershaw's field experiments in Suffolk; it was also less effective (though quite good) in some of Robertson's field experiments in Essex. In the North and West, however, where the growing season is longer, it was nearly as good as the more soluble slag of the second type. We may infer that the fluorspar slag would probably be more effective in cool, moist regions than in hot, dry ones, though more information is needed before a definite rule could be made.

The chemical or physico-chemical problem of elucidating the constitution of basic slag and determining the effective components is more difficult.

It has always been assumed that the phosphate was the effective constituent, this being the only one of the three common fertilising constituents—nitrogen, phosphorus, and potassium—present. Some importance used to be attached to the free lime until it was realised that not more than 2 to 5 per cent of free lime is present, so that the amount added to the ground is negligible. The Bessemer slag, however, produced effects on heavy grassland which could not be obtained by equivalent dressings of mineral phosphate or superphosphate. It is necessary to find some explanation for this result, and usually in Great Britain it is assumed that the phosphorus in basic slag is in the form of a silico-phosphate which may be assumed to differ in physiological action from the ordinary phosphate. Hall and Morrison (*Proc. Roy. Soc.*, 1909, 77B, 455-477) have shown that silica affects the intake of phosphorus by the plant; and the increased assimilation they obtained when silica was added to phosphate may offer an explanation of the efficacy of basic slag on grassland.

In France, on the other hand, considerable attention has been devoted to other constituents besides nitrogen, phosphorus, and potassium. Mazé (*Annales Inst. Pasteur*, 1919, xxxiii., 139-173) maintains that a large number of elements, in addition to those ordinarily recognised, including boron, aluminium, fluorine, iodine, chlorine, silicon, manganese, and zinc, are necessary for the full growth of the plant. Other workers have experimented with some of these as fertilisers, and have shown that manganese (W. E. Brenchley, *Ann. Bot.*, 1910, xxiv., 571-583; E. P. Dearrick, Cornell Univ. Ag. Mem., 1919, xix., 371-402; J. S. McHague, *Journ. Ind. Eng. Chem.*, 1919, xi., 332-5) and fluorine (A. Gautier and P. Clausmann, *Compt. Rend.*, 1910, clxviii., 976) compounds may give increases in crop From the published details in the French papers it is not evident that such increases would usually be obtained in the field, but in so far as they are obtainable at all in soil, they indicate that other constituents of slag besides phosphorus are effective. Indeed, the manganese content of slags is actually determined in France.

The experiments made in England with manganese compounds as fertilisers have not led to promising results. At Rothamsted, manganese dioxide and manganese sulphate were both tried, both succeeded to a small extent in pots, but failed in the field. At Woburn, also, some degree of success was obtained in the pot experiments. We do not, however, know of a single case in this country where manganese salts have given unexceptionable increases in crop in the field. It may always happen, however, that other compounds would be more effective, and we have started in the pot culture house a series of experiments with slags of known manganese content in order to ascertain whether manganese in the form in which it occurs in slag behaves in any way differently from the oxide or sulphate.

The idea has been put forward (probably by some of the slag grinders) that the composition of basic slag is less important than the state of grinding. It is true, of course, that a certain degree of fineness is necessary in order that the slag may have some chance of acting; Collins (Collins, "Plant Products and Chemical Fertilisers," 1918) has adduced some evidence that the standard sieve of 100 meshes to the inch affords the best results; more extended experiments, however, might well be made. But there is no evidence whatsoever for supposing that fineness of grinding is the sole factor or is anything more than an important secondary consideration. It has been asserted that a 20 per cent slag finely ground would have exactly the same effect as an equal weight of 30 per cent slag finely ground, and therefore that the low-grade slag ought to find just as ready a market as the higher grade slag. Hitherto the claim has not been taken sufficiently seriously to justify any special investigation, and the direct experiments have always been with quantities of slag containing the same amount of phosphorus.

There is, however, no indirect evidence even remotely suggesting that the addition of 5 to 10cwt. per acre of a mere gritty substance would have any appreciable effect on the soil. Many attempts have been made in the past to improve clay soils by the addition of sand; they broke down because the amounts needed per acre were not a few cwts., but many tons. The alteration of soil texture by addition of inert particles is very difficult, necessitating large amount of material.

Reviewing all the evidence, I see no reason to depart from the customary British method of regarding *the phosphorus as the essential fetilising* constituent in basic slag, though I am prepared to admit that a silico-phosphate might have a special fertiliser value, and that the basic nature of the slag is also important; as to the manganese, I have an open mind, and we are starting a series of experiments at Rothamsted on this problem.

Assuming phosphorus to be the essential fertiliser constituent, it is by no means easy to discover the form in which the phosphate exists in the different slags, or even to solve the purely analytical problem of devising a method which shall discriminate between one slag and another. In the early days there were attempts in Germany to mix cheap mineral phosphate with basic slag and to sell the mixture as a genuine article. The late Prof. Wagner then devised his well-known citric acid test for basic slag, which has become the standard method in most countries ever since. But, as Mr. Scott Robertson has shown, it does not help much for the evaluation of the new kinds of slag, and a new method seems called for.

Perhaps the most pressing problem, however, is the enrichment of basic slags poor in phosphate. In the case of the Bessemer slag this problem does not arise, because it is to the steel maker's interest to have a pig iron rich in phosphorus, and hence the slag is necessarily rich. But in the basic open hearth richness in phosphorus is not essential; indeed, it is not even desirable, and the steel maker takes no steps to ensure a phosphatic pig iron. When it is suggested that the phosphorus content of the pig iron might be increased deliberately with a view to improving the slag, the steel maker points to the relative prices of steel and slag, and reminds one that the tail must not be allowed to wag the dog. Agriculturists must remember that basic slag is a very subsidiary part of the steel maker's business, and that it cannot for a moment be allowed to increase the time necessary for making the steel, nor in any other way to increase greatly the cost of working.

On the other hand, the steel maker should realise that the agricultural demand for good basic slag is likely to be greater than the supply. The consumption of basic slag has greatly increased during the war, and there is no sign yet that the limit has been reached. The figures for the consumption in the United Kingdom are, in tons per annum :—

Pre-War.	Year ending May 31st, 1918.	1919.
263,000	500,000	540,000

Estimated amount utilisable:

Sir T. H. Middleton.	Sir Chas. Fielding.
892,000	1,463,000

It would be interesting to know from the steel makers what amount of slag calculated in terms of a slag containing 20 per cent P_2O_5 is likely to be producible in the near future. There are two distinct cases where enrichment would be desirable :—

(1) Slags containing less than 8 per cent P_2O_5 which at present are hardly used; by enrichment these might become worth grinding.

(2) Slags containig 8 to 12 per cent P_2O_5 (*i.e.*, 17·4-26 per cent tricalcic phosphate), which are already easily saleable, but which when sold on the basis of P_2O_5 content cost a disproportionately large amount in bagging, grinding, and freight.

Assuming enrichment of the pig iron to be out of the question, the only two possibilities seem to be :—

(1) Fractionation of the slag so as to concentrate the phosphorus as much as possible in one part of the slag.

This gives a product which can be more profitably handled by all concerned, though it does not increase, but rather diminishes, the total phosphorus supply.

(2) Enrichment of the slag by adding finely ground mineral phosphate in the ladle.

We are not yet in a position to pronounce a final opinion on this latter method. In its favour may be urged the fact that mineral phosphates have distinct fertiliser value, which is apparently increased by ignition, and might well be increased by any interaction taking place in the ladle.

Against it is the difficulty of detecting fraudulent additions of mineral phosphates to slag, which might become common if there were any great difference in unit price between slag phosphate and mineral phosphate—and without some difference there would be little inducement to the steel maker to enrich his slag.

A further and perhaps more difficult problem is to improve the fluorspar slags, which at present are much less soluble in citric acid than those made without additions of fluorspar. Although these insoluble slags have a higher fertiliser value than was anticipated from the old citric acid test, they do not appear to be as effective as the more soluble ones. Not only is there a falling off in yield, but probably also in quality of the crop. Pot experiments indicate that the plant takes up less phosphoric acid from an insoluble fluorspar than from a more soluble one; agricultural experience shows that increased assimilation of phosphoric acid increases the value of the crop as animal and probably as human food.

Sould it be impracticable to improve the fluorspar slags, there is still another possible solution. Agriculturists could no doubt find the precise soil and climatic conditions under which they would prove most effective, and efforts could then be made to confine their use to those particular cases. —*Transactions of the Faraday Society*, December, 1920.

Variations in the Conductivity of Calcium Sulphide due to Changes of Temperature.—When a thin layer of calcium sulphide is heated, previously insolated, its conductivity rapidly increases, passes a very acute maximum, and then decreases to become practically nil. The gradient conductivity-temperature is so much greater, the maximum so much higher, according to the greater rapidity of heating. The phenomenon is really associated with the state of phosphorescence, for when cooling is made before conductivity falls to zero, and then heating, we have much slighter variations and a much smaller maximum. M. Vaillant, who studied this phenomenon summarises his observations in this note.—*Comptes Rendus*, December 27, 1920.

THE RELATIVE VOLUMES OF THE CHEMICAL ELEMENTS.

By HAWKSWORTH COLLINS. (Continued from p. 66).

In the following the same results are obtained as in the foregoing, but without any intervening CH_2.

	Name and Chem. Formula.	Vols of Parts.	Theor. S.G.	Observed S.G.
	Chlorbenzene C_6H_5—Cl	77·48 — 23·01	1·119	1·126 20° So. 1·107 20° B.
	Brombenzene C_6H_5—Br	77·48 — 27·00	1·493	1·492 22°/4 I. 1·491 20° B.
	Iodobenzene C_6H_5—I	77·48 — 32·75	1·851	1·858 0° Sh.
	Nitrobenzene C_6H_5—NO_2	77·48 — 26·74	1·180	1·187 14° Ko. 1·174 25° Sch
120	Nitrobenzene C_6H_5—NO_2	74·45 — 26·74	1·216	1·216 5° — 10° Re.
	Aniline C_6H_5—NH_2	74·45 — 16·42	1·023	1·023 17°/4 Sw.
	Benzonitril C_6H_5—CN	77·48 — 23·96	1·015	1·010 15° Va. 1·024 25° K.
	Triazobenzene C_6H_5—N_3	(77·48 / 74·45) — 32·63	1·096	1·098 10° Va. 1·097 10° P
	Phenyl mercaptan C_6H_5—SH	77·48 — 25·48	1·07	1·078 14° V.
125	Thiophenol C_6H_5—SH	(77·48 / 74·45) — 25·48	1·084	1·074 23° Ei. ∴ 1·081 15°
	Benzoic acid C_6H_5—CO_2H	77·48 — 23·80	1·205	1·201 21° M.
	Benzoic acid C_6H_5—CO_2H	74·45 — 23·80	1·242	1·227 27° M. ∴ 1·24 15°
	Phenyl acetate C_6H_5—CO_2CH_3	77·48 — 49·71	1·07	1·074 Bo.
	Phenyl acetate C_6H_5—CO_2CH_3	(77·48 / 74·45) — 49·71	1·082	1·080 15°/15 Va.
130	Et. benzoate C_6H_5—$CO_2C_2H_5$	77·48 — 66·13	1·045	1·047 20° B. 1·049 14° De.
	Ethyl benzoate C_6H_5—$CO_2C_2H_5$	74·45 — 66·13	1·067	1·06 18° De.
	Propyl benzoate C_6H_5—$CO_2C_3H_7$	77·48 — 82·55	1·0248	1·0248 15° Sm.
	Butyl benzoate C_6H_5—$CO_2C_4H_9$	77·48 — 98·97	1·009	1·011 15° Va. 1·000 20° L.
	Amyl benzoate C_6H_5—$CO_2C_5H_{11}$	77·48 — 115·39	0·996	0·992 15° Sm. 1·002 10° Dh
135	Phenol C_6H_5—OH	74·45 — 13·29	1·071	1·070 20° B.
	Phenylacetylene C_6H_5—C_2H	77·48 — 31·25	0·938	0·937 12° Va. 0·932 25° I.
	Bromethylene (Vinyl Br) C_2H_3—Br	41·87 — 27·00	1·539	1·529 11°A. 1·566 4° Car.
	Iodethylene (Vinyl I) C_2H_3—I	41·87 — 32·75	2·064	2·09 0° Gu. ∴ 2·064 15°
	Oxalic acid CO_2H—CO_2H	23·80 — 23·80	1·9	1·900 I.
140	Methyl ethyl oxalate CH_3CO_2—$CO_2C_2H_5$	49·71 — 66·13	1·14	1·156 0°Wi. ∴ 1·142 15°
	Hexchlorethane CCl_3—CCl_3	69·74 — 69·74	1·70	1·619 Re. 2·011 S
	Bromotrichlormethane CCl_3—Br	69·74 — 27·00	2·041	2·058 0° Pt. ∴ 2·04 15°
	Methyl trichloracetate CCl_3—CO_2CH_3	69·74 — 49·71	1·486	1·489 19° H.
	Acetylene dichloride C_2H_2—Cl_2	28·89 — $(23·01)_2$	1·295	1·291 15°/4 Ch.
145	Acetylene dibromide C_2H_2—Br_2	28·89 — $(27·00)_2$	2·22	2·223 19° Sb.
	Acetylene iodide C_2H_2—I_2	28·89 — $(32·75)_2$	2·966	3·303 21° Sb. 2·942 21° Sb.
	Acetylene chlorobromide C_2H_2—ClBr	28·89 — (23·01 / 27·00)	1·781	1·816 0° Pl. 1·747 19° Sb
	Acetylene chloriodide C_2H_2—ClI	28·89 — (23·01 / 32·75)	2·227	2·229 Pl.
	Acetylene bromiodide C_2H_2—BrI	28·89 — (27·00 / 32·75)	2·62	2·627 17° Pl.

In the preceding 149 molecules it will be noticed that there are two of each of the following, phenylethylamine (Nos. 42, 44), benzyl acetate (Nos. 56, 57), nitrobenzene (Nos. 119, 120), benzoic acid (Nos. 126, 127), ethyl benzoate (Nos. 130, 131). The fact that there are two is not a fault of the theory; but, if there is a fault anywhere, it is in the large variations of specific gravity obtained by experimentalists. The *raison d'être* of these variations will appear later. It is only necessary to state here that similar variations occur in nearly all compounds of benzene. If this statement contains an actual truth, then, of course, the majority of benzene compounds will be likely to be mixtures of the two forms. This is the explanation of benzyl iodide (No. 39) being given as $\binom{77 \cdot 48}{74 \cdot 45}$—16·42—32·75. The same remark applies to several others of the foregoing compounds of benzene.

With regard to the two volumes found for OH, nothing can be said at present, except that the distinction between them will appear later.

In No 53, 49·71 is the relative volume of O—CO—CH_3, whilst in No. 54 the same figures represent the volume of CO—O—CH_3; so that the volumes of these two different arrangements of atoms are the same. The same is true of 66·13 and 82·55.

49·71, 66·13, 82·55, 98·97, and 115·39 are volumes of groups which differ by CH_2, and therefore the difference between any two of them ought to be 16·42 or a multiple of 16·42, as it is.

It has been found necessary to begin by investigating the volumes of groups of elements, but later the relative volume of each atom in these groups will become evident.

There is already no doubt at all that perfect regularity exists at the temperature of 15° C, and it remains to be seen how much further this regularity goes, and to what conclusions it leads us.

(To be continued.)

NOTE ON AUGITE FROM VESUVIUS AND ETNA.

By HENRY S. WASHINGTON and H. E. MERWIN.

THE problem of the constitution of the pyroxenes that contain alumina and ferric oxide—the augites—is one of the most puzzling and, in some respects, one of the most important that are presented by the rock-forming minerals. In an effort to aid its solution, I have made during the last few years a number of analyses of typical augites from Italian volcanoes, in the lavas of which augite is one of the most constant and most characteristic minerals. The study of these is not yet complete, and several more analyses remain to be made. But having recently completed two analyses of augite from Vesuvius and Etna, of which Dr. H. E. Merwin has determined the optical and crystallographic data, it seems to be advisable to publish the results as a slight contribution toward our knowledge of this important group of minerals. This seems to be the more justified as, notwithstanding that the species was based first on the crystals from these two volcanoes, we have as yet no satisfactory or modern analyses of them.

Augite from Vesuvius.

Vesuvius has long been noted for its pyroxenes. Beautiful diopsides are found in many of the ejected blocks of Somma, and loose crystals of augite are among the products of many of its eruptions. The crystals studied here were obtained from the bottom of the crater, in part by me in June, 1914, and in part by Dr. A. Malladra, Director of the Osservatorio Vesuviano, during the same spring. For his kindness in sending me the material for study I would express my sincere thanks.

Occurrence.—The crystals are found, either loose, and entirely or almost entirely free of scoria, as at many other volcanoes; or as phenocrysts in a highly vesicular leucite tephrite, which was being ejected in small amount from the orifice at the bottom of the funnel during my visit to it (A. Malladra, *Rend. Acad. Sci. Napoli*, Nov., 1914; Washington and Day, *Bull. Geol. Soc. Amer.*, 1915, xxvi., 375).

The crystals are mostly of the usual, well-known, simple forms, such as are figured by Dana ("System", 1892, p. 354, Figs. 16,17,18) and in most text-books of mineralogy. The faces present are: *a*(100), *b*(010), *m*(110), and *s*($\bar{1}11$). A small proportion are twinned, forming the common contact twins, with twinning plane *a*(100). They vary, in general, from 3 to 5 mm. in length (parallel to the vertical axis), though some attain lengths of 1 cm. or more. The thickness is from one-half to two-thirds of the length, and there is usually a slight tabular development parallel to *a*(100) The faces are fairly smooth and bright, much brighter than those of the Stromboli augites described in a previous paper (Kozu and Washington, *Amer. Jour. Sci.*, 1918, xlv., 463), and the edges are sharp. There is but little scoria adherent to the loose crystals, but microscopical examination of the powdered material revealed the presence of small amounts of inclusions of glass and crystalline matter (magnetic, leucite, and feldspar).

Physical Data.—Of a dozen crystals studied, four had sets of faces that were sufficiently good for approximate measurements (by Merwin). These indicate the probability that crystallographically diopside does not represent augite. The measurements were as follows:—

$m \wedge \bar{m}$ (110) $\wedge$ ($1\bar{1}0$) = 92°0'-93°57'; mean = 92°56' 4 measurements.

$s \wedge \bar{s}$ ($11\bar{1}$) $\wedge$ ($\bar{1}11$) = 61°20'-59°50'; mean = 60°36' 8 measurements.

For diopside the measurements are:—

$$m \wedge \bar{m} = 92°50', \ s \wedge \bar{s} = 59°11'.$$

Measurements of ϕ and ρ four pyramid faces, *s*, gave values of 24°23'-25°5' and 34°1'-33°15', respectively, as compared with 25°7' and 33°4' for diopside.

Speaking of the pyroxenes as a group, Dana (Dana, "System," 1892, 363) long ago pointed out: "It is noteworthy that the angles vary but little even for a wide variation in composition." While this is quite true, yet since that time, with more exact means of measurements and of chemical analysis, a more systematic study of the relations of the physical and chemical properties, and for other reasons, we are beginning to appreciate more than we did thirty years ago the probable importance of even small variations.

An optical examination showed that the Vesuvius augites studied are variable in composition. The general colour is a slightly yellowish grey, and there is little indication of zonal structure. There is little if any pleochroism. The index β varies from 1·700 to 1·711. The extinction angle is large, as usual, about 45°, but no exact measurements were made, because of the variability in composition and the consequent indeterminateness of the data.

The specific gravity of the crystal fragments used for the analysis was found to be 3·242 referred to water at 23°. This low result is probably to be ascribed to the presence of the glass inclusions.

Chemical composition.—For my analysis some of the cleanest loose crystals were selected, and, in order to obtain sufficient material, to these were added crystals obtained from specimens of the scoria from about the orifice. Great care was taken to free the crystal fragments from adherent scoria, and the analysis was made on what was probably as pure material as could be obtained from this source. It was, however, not practicable to obtain material entirely free from the small inclusions of glass, &c., and the analysis, therefore, does not represent an entirely pure augite substance. In spite of this defect, however, it is thought best to publish it, as a slight contribution to our knowledge of the Vesuvian augites, and as illustrative of the dangers, in the form of included foreign matter, that may lurk in the chemical study of many minerals. The presence of the inclusions is also of interest in view of the very close correspondence in chemical composition between these augites and a pyroxenite published by Lacroix, to be mentioned later.

TABLE I.

Analysis of Augites of Vesuvius.

	1	2	3	4
SiO_2	47·60	46·95	46·42	47·90
Al_2O_3	6·01	6·75	9·14	6·58
Fe_2O	3·17	4·47	5·03	1·52
FeO	4·59	4·09	4·87	3·33
MgO	14·43	16·04	13·19	14·20
CaO	21·52	19·02	20·86	22·51
Na_2O	0·70	n.d.	n.d.	1·14
K_2O	0·76	n.d.	n.d.	0·38
H_2O+	0·08	n d.	n.d.	0·62
TiO_2	1·52	n.d.	n.d.	1·49
P_2O_5	n.d.	n.d.	n.d.	0·70
MnO	0·13	n.d.	0·14	n.d.
SrO	none	n.d.	n.d.	n.d.
	100·51	100·32	99·65	100·39*

* Including F=0·02.

1. Augite, Crater of Vesuvius, June, 1914. Washington analyst.
2. Augite, Monte Somma. Doelter analyst. Tschermak's "Min. Petr. Mitth.", 1877, 283.
3. Augite, Vesuvius. Casoria, ref. *Zs. Kryst.*, 1907, xlii., 881.
4. Pyroxenite, Monte Somma. Pisani analyst. Lacroix, *C. R* 1917, clxv, 209.

Earlier Analyses.—The earlier analyses of Vesuvian augites, collected by Dana, Hintze, and Doelter, and most completely by Zambonini (F. Zambonini, "Mineralogia Vesuviana, 1910, 151), very unsatisfactory, either because of their early dates, or because of their incompleteness. However, two of them, which seem to be somewhat less inferior than the others, are given in Table I. While these older analyses show the general characters of augite, yet they all are seriously defective in that titanium dioxide and the alkalies are not determined in any of them, although it is clear from my analysis, and from our knowledge of augites elsewhere, that these constituents are present in distinctly appreciable amounts. The high alumina shown by them is due to the presence of titanium dioxide. Furthermore, the iron oxides are not separated in many of them. Lacroix has called attention (A. Lacroix, C. R., 1917, clxv., 211) to these serious defects in all the existing analyses of pyroxenes of Vesuvius, and I can only join with him in urging the need for better analyses of this mineral group from Vesuvius and from other localities, and incidentally, call attention to the general inferiority of the great majority of the analyses of pyroxenes, especially as regards the fundamental points of selection of pure material, and accuracy and completeness of the analyses.

The publication of analyses of such inferior quality is to be deplored, as leading possibly to seriously incorrect generalisations at the hands of those who accept blindly and without critical judgment any analysis that is offered them. One of the striking features in the study of the chemistry of minerals and rocks is the complacency with which such inferior work is accepted and published. Much of it is based on impure material, often not ascertainedly so, carried out by inexperienced analysts, by poor methods, or with impure reagents; and yet it is accepted in good faith by both analyst and author. This state of affairs has done much—much more than is generally thought—to hinder the progress of our knowledge of the chemistry of minerals.

Comparison with pyroxenite.—It is not necessary here to discuss my analysis of the Vesuvius augite, partly because of its being based on impure material, and partly because it will be discussed later, when the series of Italian augites is more nearly complete. Attention must, however, be called to the very remarkable correspondence between it and an analysis by Pisani of a pyroxenite of Monte Somma, published by Lacroix, which is given in column 4 of Table I. Lacroix does not describe this rock in detail, but it would appear to be holocrystalline and composed almost entirely of pyroxene. It is a somewhat noteworthy example of the possibility of diverse crystallisation of a part of a magma, either as a monomineralic or almost monomineralic, granular rock, or as well-formed crystals of a definite mineral.

Lacroix mentions and gives analyses of several types of the pyroxenite, all of which are more or less closely related chemically. It occurs, according to him (A. Lacroix, *C. R.* 1917, clxv., 205), as homoegogenic rocks, that is, "granular forms, not only of the flows, but also of the differentiated portions of the same magma which have not necessarily reached the surface." Such homoeogenic rocks are assumedly of abyssal origin, and, if the general theories of gravitative adjustment of Daly and Bowen are correct, they would be expected to have come up, or been carried up, as broken-off blocks, from very deep down in the volcanic mass. My augite crystals, on the other hand, occur, as has been said, in the light scorias that form the uppermost scum or froth of the ascending magma.

This would indicate that, in this case at least, separation by gravity has not been carried to completeness. That this is also true elsewhere is indicated by the occurrence of such augite crystals (almost always of the same crystal form) at other volcanoes, such as Stromboli, Etna, and the Alban volcano. Indeed, they are rather common at many volcanoes, and similarly crystals of cossyrite and kaersutite (sodic hornblende) are met with as such loose crystals at Panelleria and Linosa, to speak only of Italian volcanoes.

But the incompleteness of such a separative process is not to be wondered at, considering the convection currents in, and the presumably violent movements of, the upward-welling mass of magma, as well as the presence of gas, whose bubbles would act like those in a glass of champagne to keep up a dry raisin, which would otherwise sink ("*Forsan et haec olim meminisse juvabit*").

The interesting point is that, with portions of the magma of almost identical composition, we get, in the one case, a typically granular rock, and in the other, well-formed, loose crystals. We have, unfortunately, no detailed petrographical description of Lacroix's pyroxenites. Of some of them he says (p. 210) that they are composed of "a little leucite filling the interspaces of plates of biotite which surround *automorphic* crystals of augite or inclose them poikilitically." Of the most pyroxenic type, that of which an analysis has been cited, nothing is said as to the form of the augites; but their being spoken of as *granular* ("grenues") leads one to think that the augites are xenomorphic. We know many pyroxenites from elsewhere of this granitoid type of texture and, so far as my experience of them goes, they do not show evidence of being built around automorphic and euhedral crystal cores; though conceivably evidence of such an origin may well have been obliterated in the process of growth, if this were not zonal.

It will be evident that pyroxenites of the first type of Lacroix, with automorphic augites, would be quite in harmony with Bowen's theory of the settling of the heavy crystals in a magma (N. L Bowen, *Amer. Jour. of Sci.*, 1915, xxxix., 175). (The sinking of crystals of feldspar and their accumulation at the bottom of flows of obsidian were observed by Von Buch (Geogn. Beschr. Canar. Ins., 1825, 229), who mentions experiments made by a M. de Drée, in which feldspar crystals settled to the bottom of a crucible. The matter is discussed by C. Darwin, about 1844 ("Geological Observations," 2nd. ed., 1891, 132-140), who attempts thus to account for the differentiation of trachyte and basalt). Bowen studied the sinking of olivine and pyroxene crystals, and the rising of those of tridymite, in artificial melts, and the striking way in which the first two sank and the third rose was sufficient proof of the actuality of the phenomenon and the relative densities of crystal and liquid. So far as I know, we have few data, at least exact data, on the densities of liquid lavas, but the point arises as to whether the augite crystals are really heavier than the liquid in which they occurred.

The density of the augite crystals was determined as 3·242 at 23°. The average density of the solid leucite tephrite of Vesuvius (cf. Roth, Abh. Berl. Akad. Wiss., 1877, 13; and Zirkel, Lehrb. Petrog., 1894, iii., 10). Roth gives the average as 2·77) may be taken as about 2·8, while vom Rath (vom Rath, *Z. deutsch geol. Ges.*, 1873, xxv., 240) gives the values 2·512 and 2·592 as the densities of the glassy crusts of Vesuvian bombs of 1872, and Lagorio (Lagorio, *Tscherm. Min. petr. Mitth.*, 1887, viii., 475) 2·319 as that of a Vesuvius obsidian. We may therefore provisionally accept a density of about 2·5 for the Vesuvius glass. As to the liquid lava, we have no data; but, assuming a density of 2·8 for the solid lava, we may conclude from the discussion of Daly (R. A. Daly, *Amer. Jour. Sci.*, 1903, xv., 277) based on Mellard Reade's and Barus' data as to expansion, that the molten lava would have a density of about 2·35. This does not take into account the presence of dissolved gases, which would unquestionably lower the density, and at the same time decrease the viscosity, very materially. It is clearly evident, therefore, that augite crystals, placed in such a leucite tephrite magma, would be much more dense than the magma, and would tend to sink, though the actual sinking of many of them would be more or less prevented by movements in the liquid, and by the possible presence of attached gas bubbles in the upper portions of the mass. Anyone who has made mineral separations with heavy liquids will appreciate the possibilities of disturbance of a "theoretically" perfect separation, adherent particles of the lighter minerals here replacing the gas bubbles of the magma.

But the occurrence of masses of rock of granitic texture, without euhedral crystals, or crystals formed freely in the body of the liquid, of the same composition as such crystals formed in what must have been a very similar magma and at the same volcano, seems to demand the recognition of some other factor than gravity, or at least one in addition to that of gravity.

This is not the place to enter into a discussion of the various kinds or causes of differentiation that have been suggested, but I must recall the case of Shonkin Sag and the explanation of its differentiation by fractional crystallisation advanced by the late Prof. Pirsson, which, it seems to me, Daly has not adequately met by an appeal to gravitative differentiation (L. V. Pirrson, *Amer. Jour. Sci.*, 1901, xi., 12; U.S. Geol. Survey, *Bull.* 237, 1905, 188. Cf. Daly, "Igneous Rocks and their Origin," 1914, 223, 238). Pirrson and I held much the same views on these matters, and I feel inclined to revive a theory put forward many years ago (Washington, *Bull.* Geol. Soc. Amer., 1900, xi., 409, 414; *Jour. Geol.*, 1901, ix., 663), chiefly to account for the different types of laccolithic differentiation. This is based on fractional crystallisation, perhaps aided by convection currents, as Pirrson supposed, the crystallisation beginning at the rough walls, and the crystals of this portion (in the present case monomineralic) interfering with each other so as to produce a granitoid textured rock. Crystallisation of free floating crystals (therefore euhedral) in the magma could, and probably would, also go on simultaneously. The process is analogous to the slow freezing of a bottle of salt solution, which begins at the walls, so that clear ice forms above, at the sides, and at the bottom, leaving finally a central core of highly concentrated solution. With the more complex rock magmas the process would be conceivably more complex than this, but the

same general principles would seem to apply. Unquestionably, the influence of gravity might or would be felt, especially on the loose floating crystals, but this would probably have less or no effect on the wall accumulations. The process is analogous to Daly's chilled border concept, but differs from this in that, according to Pirrson's and my hypothesis, the border crystallisation product does not represent the original magma, as conceived by Daly, but would be an "extreme pole of differentiation."

(To be continued.)

BRITISH INDUSTRIES FAIR, 1921.

February 21—March 4.

In a few days' time the British Industries Fair, London, for 1921, will be opening its doors at the White City to the buyers of the world. This will be the seventh London Fair, and promises to surpass its predecessor even as that in its turn added to the roll of success. It is estimated that there will be some 3½ miles of stands displaying British goods at the White City. Since its inception in 1915, the record of the British Industries Fair has been one of continuous growth in scope, utility, and reputation. Started as a means of promoting the manufacture in the United Kingdom of articles previously made in enemy countries, the Fair made so instant an appeal and received such warm support from its exhibitors, that it has never looked back, and is now established in a predominant position among the great trade fairs of the world. The secret of this success is not far to seek; the British Industries Fair is a *business exhibition for business men.* Producing trades are carefully grouped for the convenience of the inspecting buyer, and these groups are again split up into sections and so housed and exhibited as to facilitate to the utmost a rapid and thorough survey of British production in any given line. The foreign buyer is invited by the Department of Overseas Trade, and invitations only extended to *bona fide* firms and representatives, thus enabling both buyer and seller to conduct their business unhampered by a crowd of sightseers. Participation in the Fair, limited to manufacturers in specified British trades, is both cheap and simple, offering equal opportunities to both large and small firms. This year's exhibitors cover both categories, and form the most representative body of British manufacturers ever assembled. Their names alone are a guarantee of the quality of the goods to be displayed and their keenness to exhibit is shown by the fact that the available space in every section of the Fair has been applied for several times over.

The goods to be displayed in the London Section include books, cutlery, silver and electroplate, jewellery, watches, and clocks, hard haberdashery, glassware of all descriptions, china, earthenware and stoneware, paper, stationery and stationer's sundries, printing, fancy goods, including travelling requisites and tobacconists' sundries, medical and surgical instruments and appliances, leather for the fancy goods, bookbinding, and upholstery trades, brushes and brooms, toys and games, sports' goods, scientific and optical instruments, spectacle ware and opticians' supplies, photographic and cinematograph apparatus and requisites, drugs and druggists' sundries, musical instruments, furniture other than metal, basketware.

The Birmingham Fair also opens on Feb. 21, at the Castle Bromwich Aerodrome. The oversea visitor will have the opportunity to inspect some 20 sections covering the trades for which that city is world-famous Every type of fitting for lighting and cooking, and a wide range of hardware, including household ironmongery will be on display, together with metal furniture and saddlery, indiarubber goods and motor accessories. In fact, almost every branch of the British metal industry will be represented.

The exhibits at the well-known Kelvin Hall, Glasgow, will include textiles of all sorts, ready-made clothing, hats, boots, carpets, foodstuffs, chemicals, and dyes. This Fair opens and closes a week later than the London and Birmingham Sections

So much for the home end of the Fair. A good show is guaranteed; what of the use to which it will be put? Never has the foreign buyer had a more favourable opportunity for purchasing in our markets. The tremendous demand prevailing in the home market early last year has fallen to below normal, contracts have had to be cancelled or curtailed, with the result that the British manufacturer has ample stock in hand to meet new orders. No opportunity has been missed by the Department of Overseas Trade and the organisers of the Birmingham and Glasgow Sections of bringing those favourable conditions to the notice of the foreign buyer.

With the financial support of the exhibitors, the Department of Overseas Trade has conducted a wide publicity campaign in the oversea press, in addition to the normal propaganda activities. Reports so far received promise excellent results. Invitations have been issued to some 60,000 overseas buyers of standing, and the same number of illustrated booklets, translated into eight languages, have been issued all over the world. Liberal use has also been made of showcards with the assistance of overseas banks, shipping companies and the Consular Diplomatic Officers of the Department in all parts of the world. Excellent reports as to the number of visiting buyers have been received from Scandinavia, where special conducted tours during the Fair are being arranged. From the United States, also, the prospects of a large number of visitors are favourable. Switzerland, Finland, Canada, and Italy are among countries where interest in the Fair is also reported as being considerable. Many committees, both official and unofficial, in this country are studying the question of the entertainment of the oversea visitor. During the period of the Fair, it is hoped that official foreign commercial missions will visit this country as guests of the British Government.

The White City not only provides the exceptional floor space necessary for the British Industries Fair (35,000,000 cubic feet are available), but has the merit of being easily accessible. The exhibition buildings are grouped between five railway stations, all giving direct access. Twenty minutes by taxi will cover the journey from all parts of the West End.

THE THEORY OF RELATIVITY.

NO scientific subject has excited so much discussion in recent years as the Principle of Relativity developed by Lorentz, Einstein, and Minkowski. Since the work of Faraday and Clerk Maxwell, the existence of an all-pervading æther has been an accepted doctrine of physical science. The æther was conceived as stationary, yet all tests—like that of the classical experiment of Michelson and Morley—failed to detect the movement of the earth through it. FitzGerald suggested that the dimensions of the apparatus were affected by the movement. On the theory of the electromagnetic constitution of matter, Larmor and Lorentz worked out mathematically the consequences of this view. The conclusion was reached that no experiments could ever reveal absolute motion. Einstein showed that remarkable consequences as to the time and space followed from this proposition, necessitating a new mental picture of the physical universe. The details of this conception constitute his presentation of the Theory of Relativity.

Many physicists find it difficult to abandon the idea of the existence of the æther as they have come to think of it, and do not consider such a revolutionary change of thought is necessary as is involved in the complete acceptance of the principle. The different aspects of the theory are described in the important articles published in the special issue of *Nature* on February 17. The contributions constitute the most authoritative scientific statemen on relativity from different points of view yet published, and the number will be of permanent value.

The articles will include the following:—

"A Brief Outline of the Development of the Theory of Relativity" by Prof. A. Einstein.
"The Michelson-Morley Experiment and the Dimensions of Moving Bodies," by Prof. H. A. Lorentz, For.Mem.R.S.
"Electricity and Gravitation," by Prof. H. Weyl.
"Theory and Experiment in Relativity," by Dr. Norman R. Campbell.
"The Metaphysical Aspects of Relativity," by Prof. H. Wildon Carr.
"Relativity and the Motion of Mercury's Perihelion," by Dr. A. C. D. Crommelin.
"Relativity: the Growth of an Idea," by E. Cunningham.
"Relativity and the Eclipse Observations of May, 1919," By Sir Frank Dyson, F.R.S.
"The Relativity of Time," by Prof. A. S. Eddington, F.R.S.
"The General Physical Theory of Relativity," by J. H. Jeans, Sec. R.S.
"The Geometrisation of Physics, and its Supposed Basis on the Michelson-Morley Experiment," by Sir Oliver Lodge, F.R.S.
"Non-Euclidean Geometries," by Prof. G. B. Matthews, F.R.S.
"On the Displacement of Solar Lines," By Dr. C. E. St. John.
"The Relation between Geometry and Einstein's Theory of Gravitation," by Dorothy Wrinch and Dr. Harold Jeffreys.
Bibliography of Books and Pamphlets on Relativity.

CORRESPONDENCE.

DYESTUFFS (IMPORT REGULATION) ACT, 1920.

To the Editor of the Chemical News.

SIR,—The Council of the Institute of Chemistry have addressed a letter to the Board of Trade, enquiring whether licenses would be necessary under the Dyestuffs (Import Regulation) Act, 1920, for the import of small quantities of organic chemicals (including intermediate products used in the manufacture of dyestuffs, &c.), required solely for research purposes. I enclose herewith a copy of the reply received.—I am, &c.,

RICHARD B. PILCHER.
(Registrar and Secretary).

[Copy] Board of Trade.
(Industries and Manufactures Department
8th *February*, 1921.

SIR,—With further reference to your letter of the 28th January, regarding the Dyestuffs (Import Regulation) Act, 1920, I am directed by the Board of Trade to state that, whilst it is not possible to regard small quantities of organic intermediate products which may be required for research purposes as being outside the scope of the Act, the Board will be prepared to issue general licenses for the importation of such products to approved research institutions, covering periods of three months and limited only as to total quantities. This procedure will obviate the necessity for separate applications for a large number of small items, but it will be a condition of the issue of any general license that a detailed return shall be furnished at the end of the three months during which the license is in operation, of the quantities of each product actually imported under it.—I am, Sir, your obedient servant,

(Signed) PERCY ASHLEY

The Registrar & Secretary,
Institute of Chemistry of Great Britain & Ireland,
30, Russell Square, W.C.1.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxxi, No. 22. November 20, 1920.

CONSTITUTION OF THE PARAMOLYBDATES.—M. S. Posternak.—Delafontaine showed (*Arch. Sc. phys. et natur.*, 1865, xxiii., 5) that the composition of ordinary ammonium molybdate and the corresponding salts of sodium and potassium could be expressed by the general formula

$$3R_2O.7MoO_3+NAg,$$

these salts being termed the paramolydates, in distinction to the ortho and metamolybdates. The latter are dibasic, whereas the paramolybdates are hexabasic. Blomstrand proposed $MO^{vi}(OMoO_2OR)_6$ as the formula for the paramolybdates. Copaux[1] gave as the formula $R_6[MoO_3(Mo_2O_7)_3]$, both these expressions deriving the salts from a hexavalent molybdic acid

($Mo(OH)_6$), unknown by them. Rosenheim (*Zeit. f. anorg. Chemie*, 1916, xcvi., 139) brought forward a theory that for the most part the polymolybdates were derived from a hypothetic aqueous acid $H_{10}(H_2O_6)$, each oxygen atom being capable of replacement by a bivalent MoO_4 or Mo_2O_7 group, which gives two series of salts of more or less saturated acids $H_{10}[H_2(MoO_4)_6]$ and $H_{10}[H_2(Mo_2O_7)_6]$. Ordinary ammonium molybdate $3(NH_4)_2O.7MoO_3+4H_2O$, under this hypothesis becomes $(NH_4)_5H_5[H_2(MoO_4)_6]$, a pentabasic salt of aquahexamolybdic acid. This theory of Rosenheim's is subject to criticism, for the author has been able to prepare ammonium paramolybdate in the anhydrous state, showing that the $4H_2O$ given by Delafontaine's formula is water of crystallisation and not as in Rosenheim's formula part of the constitution. The author has also prepared two new ammonium salts intermediate between the para and metamolybdates; the mono and triammonium heptamolybdates $NH_4O(OH)_2MoO(O.MoO_2)_5.MoO_2(OH)+H_2O$ and $(NH_4O)_3MoO(O.MoO_2)_5O.MoO_2(OH)$. The constitution of these salts show that ammonium paramolybdate should be written :—

$$(NH_4O)_3MoO(O.MoO_2)_5O.MoO(ONH_4)_3+4H_2O.$$

The author then gives a short account of the method of preparation of anhydrous hexa-ammonium heptamolybdate, mono and triammonium heptamolybdates.

Vol. clxxii., No. 2. January 10, 1921.

Tetrabasic Polymolybdates.—M. S. Posternak. —The author in examinng the changes of composition brought about by ammonium phosphomolybdate, arrived at the conclusion that molybdic acid, in a strong acid solution, contained tetravalent molybdenum, in fact, he prepared trihydroxyammonium tetramolybdate.

$$NH_4O(OH)_2MoO(O.MoO_2)_3OH+5H_2O,$$

by mixing 100 cc. of 10 per cent solution of ordinary ammonium molybdate with 25 cc. of 2 normal H_2SO_4 and 10 grms. of ammonium sulphate. This salt loses $5H_2O$ in a sulphuric atmosphere, and still a further H_2O when heated in an oven to 130°-160°. Rosenheim (*Zeitsch. f. anorg. Chemie.*, 1897, xv., 180) who has prepared the same compound, and estimated the water by difference, called the salt an octomolybdate $(NH_4)_2O.8MoO_3+13H_2O$, in accordance with the old classification of Ullik (*Ann. der Ch. und Pharm.*, 1867, cxliv., 204, 320). The properties of this salt are important for the polymolybdate theory. Dissolved in water, it becomes unstable; these aqueous solutions warmed on a water-bath or maintained at 40° in an oven, deposit short needles having the composition of a trihydroxyammonium pentamolybdate.

$$NH_4O(OH)_2.MoO(O.MoO_2)_4OH,$$

an anhydrous salt losing an H_2O molecule from its constitution on being heated to 130°-160°, acting similarly to all the series of salts having two neighbouring hydroxyl groups. Rosenheim and Felix (*Zeitsch. f. anorg. Chemie.*, 1913, lxxix., 292) considered it to be a decamolybdate

$$(NH_4)_2O.10MoO_3+3H_2O.$$

The mother-liquors on being allowed to crystallise give a hexammonium dodecamolybdate. If the tetramolybdate is allowed to recrystallise twice in four parts of water at 75°, taking care to filter off the insoluble, it is transformed into trihydroxyammonium tridecamolybdate

$$(NH_4O)_3MoO(O.MoO_2)_{11}O.MoO(OH)_3+19H_2O.$$

NOTES.

Institute of Metals.—At the Annual General Meeting, March 9 and 10, 1921, the following papers are expected to be submitted in the order given :—

Wednesday, March 9 (Morning Session, 10.30 a.m. to 1 p.m.)—(1) "Stages in the Re-Crystallisation of Aluminium Sheet on Heating, with a Note on the Birth of Crystals in Strained Metals and Alloys," by Prof. H. C. H. Carpenter, M.A., Ph.D., A.R.S.M, F.R.S., Past-President, and Constance F. Elam, Member (London). (2) "Some Notes on Calcium," by P. H. Brace (East Pittsburgh, Pa., U.S.A.), (presented by Dr. J. L. Haughton).

Wednesday, March 9 (Afternoon Session, 2.30 p.m. to 4.30 p.m.). (3) "Plastic Deformation of some Copper Alloys at Elevated Temperatures," by Prof. C. A. Edwards, D.Sc., Member, and A. M. Herbert (Swansea). (4) "The Action of Reducing Gases on Heated Copper," by H. Moore, O.B.E., B.Sc., Member, and S. Beckinsale, B.Sc. (Woolwich).

Thursday, March 10 (Morning Session, 10.30 a.m. to 12.30 p.m.). (5) "The Season Cracking of Brass and other Copper Alloys," by H. Moore, O.B.E., B.Sc., Member, S. Beckinsale, B.Sc., and Clarice E. Mallinson, M.B.E., B.Sc. (Woolwich). (6) "Constitution of the Alloys of Copper with Tin, Parts III and IV.," by J. L. Haughton, D.Sc., F.Inst.P., Member (Teddington).

Vegetable Alkaloids.—Very often, as is known, the hydrogen of the hydroxylic aminic and iminic groups is replaced by alcohol or alcoholic radicals. Messrs. Ciamician and Ravenna demonstrate that the latter augment the noxious action of the fundamental substances which contain them, but when the fundamental compound, non-toxic, is normally present in the plant, its derivatives are not so. In any case, the most poisonous substances are those which best resist the action of oxidising ferments and the effect of the organic substances on plants should be in relation to the resistance they offer to their elimination.—*Comptes Rendus*, November 2, 1920.

The Council of the University of Birmingham, in their Annual Report, state that Sir John Cadman felt compelled to resign his professorship of mining engineering on his appointment as adviser to the Cabinet on questions affecting coal and petroleum. As it was not found possible to secure a suitable occupant for the Chair, Sir John had accepted an invitation from the Council still to act as professor in this department and adviser in the department of petroleum technology, giving such time to the office as his other duties permitted, with an honorarium of £500 a year.

Royal Institution.—The Managers of the Royal Institution, in accordance with the Actonian Trust Deed, have awarded the Actonian Prize to Prof.

G. E. Hale, D.Sc., LL.D., F.R.S., Director of the Mount Wilson Solar Observatory, for his contributions to solar physics

PROBLEMS OF MODERN SCIENCE.—The principal subject chosen for the lecture on "Modern Problems in Chemistry" at King's College (University of London), was the development of the chemistry of natural products. The lecturer introduced the subject by giving an outline of the history of organic chemistry from this standpoint, and showed how the ideas of the structure of carbon compounds had grown, and how these had been applied to the artificial production of many substances obtained originally from natural sources. After a description of the achievements of synthetical organic chemistry in this field the lecturer explained how recent efforts of chemists had been directed to the study of the processes actually employed by the plant. The occurrence of form aldehyde in the leaves of plants had been demonstrated and this substance had been artificially produced from carbonic acid and water under the influence of light and from carbonic acid by the action of magnesium. In this way a probable explanation was obtained of the initial stages in assimilation of carbon by the living plant. Moreover, it had been further shown that formaldehyde may be converted into sugars and thus an indication given of how the more complex substances of this kind may be produced in plant life. The nature of enzymes was also described, and their probable function in the chemical changes taking place in plants was pointed out. Finally, the lecturer described the chief problems which await immediate solution in this field of research.

PROPERTIES AND CONSTITUTION OF THE GROUP $OCCl_3$.—Messrs. Kling and Florentin specify in this note the properties of the group $OCCl_3$ which they studied subsequently to their researches on the products of chlorinated substitution of chloroformates.—*Comptes Rendus*, January 3, 1921.

MINERAL RESOURCES OF GREAT BRITAIN.—The Ministry of Agriculture and Fisheries desire to give notice of the publication of Volume No. XIV. of the Special Reports on the Mineral Resources of Great Britain which have been prepared by the Director of the Geological Survey in response to numerous enquiries that arose through conditions brought about by the late war. Price 8s. net. This volume contains a brief but comprehensive account of the geology of the fire-clay deposits of great Britain, with especial reference to those beds which are at present employed for the manufacture of fire-bricks, furnace-linings, and other refractory materials. The industry is an old-established one, and, especially during the war, was of great national importance. The British fire-clays are described according to the counties in which they occur, and particulars are given of every deposit that is known to be of economic value. Fortunately for the country there is an abundant supply of fire-clay, and the reserves are large, while the variety of clays is such that almost every use to which the mineral is put can be adequately provided for from home sources. This volume is a sequel to the Memoir on Siliceous Refractories previously published, and it is intended to issue another part containing chemical analyses and furnace-tests of many of the best-known fire-clays. Copies can be obtained from any Agent for the sale of Ordnance Survey and Geological Survey Maps, or through any Bookseller, or from the Director-General, Ordnance Survey Office, Southampton.

NEW METHOD FOR COLORIMETRIC ANALYSIS OF SMALL QUANTITIES OF URANIUM.—This method by Muller is based upon the formation of a red compound with salicylic acid (5 cubic metres of the salt of uranyl and 5 of a 2 per cent soda solution of salicyclic acid. A uranyl nitrate solution is treated in the same manner, and comparison made with the Dubose colorimeter. Thus the percentage of uranium can be estimated to about 0·02 per cent. The solution must not contain free mineral acids, and even a large proportion of acetic acid is inconvenient. Thus acid solutions should be treated with excess of sodium acetate, the acid being then eliminated by ebullition. There must be no iron. Alcohol and acetone are obstacles.—*Chimie et Industrie*, November, 1920.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

3377—Akt-Ges. fur Anilin-Fabrikation—Process for protecting animal fibres in treating them with alkaline liquids. Jan. 27th.

3369—Bawden, C.—Manufacture of ortho-nitro phenol and para-nitro phenol. Jan. 27th.

3370—Bawden, C.—Separation of ortho.- and para-nitro chlor benzines from mixtures thereof. Jan. 27th.

3371—Douse, D. F.—Manufacture of ethyl-chloroformic ester. Jan. 27th.

2921—Freeth, F. A.—Production of ammonium chloride and sodium carbonate. Jan. 24th.

3032—Prager, H. A.—Manufacture of naphthalene compounds. Jan. 24th.

3033—South Metropolitan Gas Co.—Manufacture of ammonium sulphate. Jan. 24th.

Specification published this Week.

157578—Sidgwick, N. V., Plant, S. G. P. and Boake Roberts & Co. Ltd.—Preparation and manufacture of di-ethyl sulphite.

Abstract Published this Week.

Acetic Acid.—Mr. H. Dreyfus of Waterloo Place, London has recently been granted a Patent No. 154680 for improvements in the manufacture of acetic acid by oxidation of aetaldehyde at 10-20° C., the catalyst employed is the residue which remains after igniting the carbon from animal charcoal, with or without the addition of sodium acetate. As the residue mainly consists of calcium and magnesium phosphates, it may be replaced by a mixture of these compounds with or without small quantities of lime, silican dioxide, and fluorides.

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MEETINGS FOR THE WEEK.

Monday, February 21.

Royal Society of Arts, 8. "Applications of Catalysis to Industrial Chemistry," by Dr. Eric K. Rideal.

Tuesday, February 22.

Royal Institution, 3. "Darwin's Theory of Man's Origin (in the Light of Present Day Evidence) by Arthur Keith.
Society of Chemical Industry, (At Glasgow).
Institution of Petroleum Technologists, 5.30.
Institution of Electrical Engineers, 7 (At Leeds and Manchester).

Wednesday, February 23.

Royal Society of Arts, 8. "Premature Elevators in Theory and Practice" by Dr. William Cramp.
Society of Chemical Industry, 7. (At Nottingham).
Institution of Electrical Engineers, 7. (At Birmingham).

Thursday, February 24.

Royal Institution, 3. "Mason Bees" by Frank Balfour Browne
Institution of Electrical Engineers, 6.

Friday, February 25.

Royal Institution, 9. "The American Civil War" by John Buchan.
Physical Society, 5.

Saturday, February 26.

Royal Institution, 3. "Spectroscopy—Celestial Spectroscopy," by A. Fowler.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

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THE CHEMICAL NEWS.

VOL. CXXII., No. 3176.

THE THEORY OF AUXILIARY VALENCIES AND "WATER OF CRYSTALLISATION."

By H. T. F. RHODES.

THE theory of auxiliary valencies, first enunciated by Werner, was designed to account for the existence of some compounds that have been variously termed "molecular complexes" and "compounds of higher orders," &c.

Apparent abnormalities in valency undoubtedly exist, and strictly speaking, it is very doubtful if, in the present state of our knowledge any definite statement about valency can be made, since, particularly with regard to "water of crystallisation," we are faced with a large and increasing number of compounds that seem to suggest that their capacity for affinity is much greater than the ordinary facts concerning their valency would lead us to suppose. For example, it is only necessary to mention the "alums" that crystallise with twelve molecules of water; and although it may be argued that this water is not in chemical combination with the salt, it can only be answered that—save perhaps in some cases which will be considered under "Conclusions"—we have no evidence that it is not; and on the other hand we are faced with the fact that these salts combine with a definite quantity of water. Indeed, all the evidence goes to show that these are, in some sense, chemical compounds. For example, great heat is generated when water comes into contact with dehydrated salts—copper sulphate is a notable example; and also in connection with this same salt there is the question of its sharp changes in vapour pressure, corresponding to well-defined hydrates when the anhydrous salt is treated with a water vapour in a closed vessel; indirect evidence that favours this view.

A short discussion of Werner's theory will not be out of place, and is, indeed, necessary to the subject before us.

The theory has given rise to some criticism, and the author himself—whose untimely death we have reason most deeply to regret—was among those who admitted the difficulties it involved. The theory is concerned with the idea that simple molecules possess an residual affinity in virtue of which more complex molecules can be constructed. This property belongs to the nucleus atom; for example, the oxygen atom of water, the sulphur in sulphur trioxide. It is postulated, however, that this residual affinity cannot effect a combination which falls within the definition of normal valency, although it is not supposed that the mode of action is different. Werner's co-ordination number is defined as the binding power that the primary and secondary valencies can together effect.

This would seem to be a fair definition, and even before discussing the question of the constitution of compounds, a formidable difficulty presents itself in the manner that save for the fact that secondary valencies seem to be in some sense a molecular phenomenon, it is difficult to draw a distinction between the two kinds of valency; and very properly, even this molecular question is tolerant of no loose interpretation, since Werner's definition of the co-ordination number insists upon this central atom as indeed it must, in order to save the existing definition of valency from grievous violence. This in itself tends to support the idea that there is no difference between the two kinds of valency, and as a corollary it seems difficult to escape the conclusion that auxiliary valencies have no real existence.

On the other hand, it is possible to assume that the auxiliary valencies do not differ in nature but in degree; and it is this aspect of the case that will be considered in the light of some of Werner's structural formulæ.

Werner assigns to ammonium chloride the structural formula :—

$$\left[\begin{array}{ccc} H. & & .H \\ & N & \\ H\cdot & & \cdot H \end{array}\right] Cl$$

that is to say that nitrogen is normally tervalent in ammonia and that it possesses one secondary valency making its co-ordination number four. Now if a difference in degree between primary and secondary valencies be admitted, then the four that include one that is weaker than the others operate with the four hydrogen valencies that are (because of heir normality) equal. It is impossible to discuss here the difficulties that this involves, but *prima facie* the conclusion is unsatisfactory. It is answered by the fact that a state of equilibrium may be supposed to exist, and undoubtedly under such circumstances some state of equilibrium must prevail if we are not to assume a kind of hysterisis, but it does not destroy the uncomfortable conclusion that the nucleus is fundamentally weak. But the position assigned to chlorine atom makes the difficulty the greater. It is amenable to the same objection (although not for the same reasons, in particular) that Friend (Friend, *Trans. Chem. Soc.*, 1916, p. 715) has alleged against the position of the chlorine atoms in hexamine cobaltic chloride and monochlorpentamine cobaltic chloride "since it hovers in an indefinite manner around the nucleus as a whole." In fine, such a formula suggests instability, an instability that experiment does not confirm. The comparative ease with which ammonium chloride dissociates is not evidence of instability, since it is impossible to judge the ammonium salts by a standard to which they are unqualified to conform. Taking into consideration the complex nature of the basic radicle, the ammonium salts are very stable.

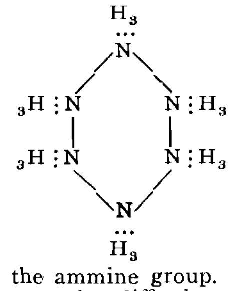
The difficulty is at least as great in the case of those salts that contain "water of crystallisation." Werner has assumed that the same principle is applicable, and he has accordingly written the formula of hydrated magnesium chloride, $Mg.Cl_2.6H_2O$.

$$Cl \left[\begin{array}{c} OH_2 \\ {}_2HO\cdot\ \ \cdot OH_2 \\ Mg \\ {}_2HO\cdot\ \ \cdot OH_2 \\ OH_2 \end{array}\right] Cl$$

which gives to magnesium a co-ordination number of six. It is true that magnesium chloride is unstable and that water cannot be removed from it without decomposition, but in order to establish the validity of the hypothesis it should be true of all

such salts, or of nearly all, and it is not; since, in general, those salts that contain six or more molecules of water are not on that account the less stable. The foregoing all tends to show that the case for the co-ordination number is very weak, and we are driven to the conclusion, therefore, that some modification is necessary.

Friend's heterocyclic theory of valency (Friend, *Trans. Chem. Soc.*, 1909, xciii., 1006; and 1908, 260, xciii., 11, 166, 441, 454) has been advanced to overcome these difficulties. The ammines are discussed and the structure



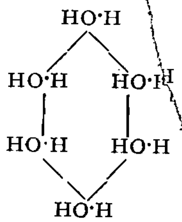
suggested for the ammine group.

This overcomes the difficulty with regard to these compounds, and is certainly the most satisfactory theory yet advanced.

In dealing with the question of water of crystallisation, a like assumption has been made by the present author, but it seems not improbable that the exercisation of some force (hereafter called molecular affinity) may hold the hydroxyl ring. Werner has credited, for example, the chlorine atoms in $MgCl_2.6H_2O$ with this property, but to say the least, this is most undesirable, since it is necessary under these circumstances to suppress the valency of chlorine. On the other hand, no such objection can be alleged in the case of the ring, since it possesses no free valency. It is doubtful, nevertheless, if such a conclusion is sound, but it has been included as a possible alternative.

Armstrong suggested that modifications of water existed on the assumption that oxygen may be quadrivalent, thus :—

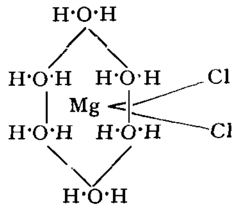
The evidence he adduces is certainly worthy of consideration, and it intimately concerns the question before us. A ring structure has also been assigned to water (see Kohlrauch, *Proc. Roy. Soc.*, 1903, lxxi., 338) :—



Now from an examination of a list of those salts that contain water of crystallisation reveals the interesting and significant fact that the most numerous class is that which contains salts with six, seven, or twelve molecules of water.

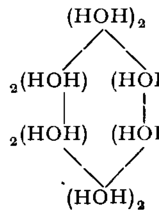
H_2O	Per cent.	H_2O	Per cent
1	4	10	—
2	6	11	—
3	8	12	—
4 and 8	16	13	—
5 and 10	19	14	—
6, 12, 7	38	15	.2
7	—	16	—
8	—	17	—
9	4	18	3

$X.6H_2O$.—If the ring structure be allowed, this at once disposes of salts that contain six molecules of water. For example, the hydrate of magnesium chloride becomes :—

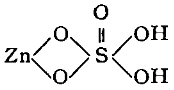


The considerations for and against this and the succeeding structural formulæ will appear under "Conclusions."

$X12H_2O$.—In this case the molecules may be regarded as polmerised thus :—



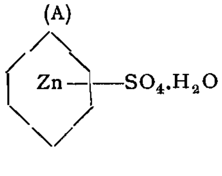
* * The little evidence that we possess is in favour of the idea that those salts containing seven molecules of water, which are principally sulphates, have one molecule in normal combination :—



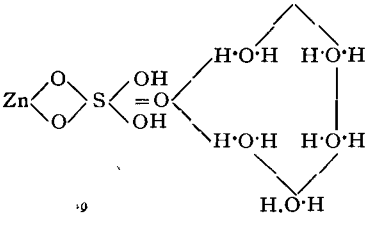
* * Zinc sulphate loses six waters at 100° C. and the seventh at red heat.

$X.7H_2O$.—Two possible formulæ would seem to suggest themselves therefore :—

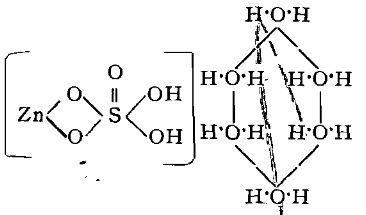
(A)



(B)

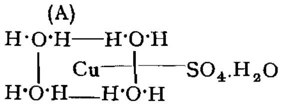


"A" appears to be the sounder of the two formulae as the second may seem to be unduly speculative; but it is included as an alternative the better to illustrate and to compare with one of the formulæ it is proposed to assign to copper sulphate—for sufficient reason, as will be seen when salts containing three molecules of water are discussed. In the second place the structure below is illustrative of this theory of molecular affinity. It is unnecessary and it may even be undesirable to suppose that the affinity is manifested about the hydroxyl, since it has been assumed that affinity is the product of the molecule as a whole, and the position of the hydroxyl ring may therefore be indefinite. But at the same time, if combination with itself be a property of water under certain conditions, there is something to be said for the attachment of the ring at that part of he molecule where the elements of water already exist.

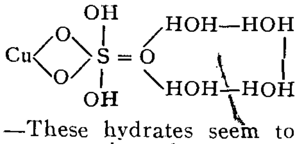


X.$5H_2O$.—Some sulphates are associated with five molecules of water, and of these copper sulphate is a convenient example. As with zinc sulphate, one molecule of water is regarded as being in normal combination, and for the same reason. Formula A is probably more sound, but formula B is illustrative of the principal that it may be justifiable to include in the aqueous ring groups other than HOH groups.

(A)

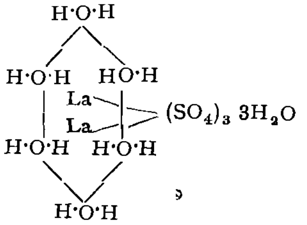


(B)

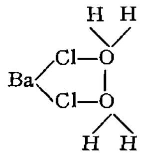


X.4HO and X.8HO.—These hydrates seem to call for no particular comment since they may be regarded as analogous to formula A above, less the molecule of combined water.

X.9HO.—It is interesting to observe that nine waters of crystallisation are associated with the "ic" sulphates, notably those of lanthanum and iron. And since they might be assumed to hold in combination three molecules of water, normally, the hydroxyl ring may in this case be applicable .

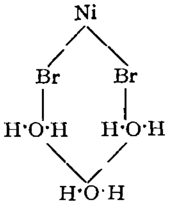


X.2HO.—This modification need not detain us long, since most of the salts are halides to which the formula below—quoted in most modern text-books— may be assigned.



This formula assumes, of course, the tervalency of chlorine, and quadrivalency of oxygen.

X.$3H_2O$.—In connection with those salts that contain three molecules of water, an interesting question presents itself. Their number is small, and for the most part they can be explained by the assumption that the water is in true hydroxyl combination; but among their number is a halide of nickel. This might be represented by the formula :—



This introduces the point as to whether it is justifiable to allow substitutions in the hydroxyl ring, for, granting this, formula B for copper sulphate may also be accepted as an alternative.

It only remains to allude to those salts that possess fifteen or eighteen molecules of water. Aluminium nitrate and aluminium and chromium sulphates correspond respectively, and are, it would seem, the only examples. Aluminium sulphate may be assumed to hold in true combination six molecules of water, and the remaining twelve molecules may form a polymerised hydroxyl ring, but it is extremely doubtful if there be any grounds for supposing that the nitrate can combine with water in any proportions, nor, if it be possible, does any ring formula prove itself *ad rem.* These salts of aluminium are, however, isolated exceptions.

(To be continued)

Royal Society.—At the meeting of May 12, a Discussion on "The Quantum Theory of Line-Spectra" will be opened by Sir Ernest Rutherford, followed by Dr. N. Bohr.

Royal Institution.—On Saturday, March 5, at 3 o'clock, Sir Ernest Rutherford will deliver the first of a course of three lectures at the Royal Institution on "Electricity and Matter," and on Tuesday, March 8, Dr. G. C. Simpson, Director of the Meteorological Office, commences a course of two lectures on the "Meteorology of the Antarctic." The Friday evening discourse on March 4 will be delivered by Mr. W. A. Tait on "Severn Crossings and Tidal Power"; on March 11 by Dr. J. Freeman on "Medical Idiosyncrasies"; and on March 18 by Sir Frederick Bridge on the "Researches of a Musical Antiquarian."

THE ALLUVIAL DIAMONDIFEROUS DEPOSITS OF SOUTH AND SOUTH-WEST AFRICA.*

By FRED. C. CORNELL, O.B.E.

In 1867, during a period of the greatest depression, in South Africa, when droughts of exceptional severity had killed off a large proportion of the flocks and herds, when a new and greatly resented duty upon Colonial wines had practically resulted in the loss of the Home market, and when, in short, prospects appeared most gloomy, a new lease of life was given to the country by the discovery of diamonds; a discovery which, pooh-poohed at first, was soon amply confirmed, and which was to bring about an industry of tremendous wealth, and of world-wide importance.

The first diamonds were discovered in the district of Hope Town, near the Orange River, but the bands of adventurous spirits which the discovery attracted to the spot, soon wandered to the banks of the Vaal River, where finds were much more plentiful; and it is along the latter river and not the Orange, that the principal "River Diggings" are to be found.

At first attention was only paid to the gravel adjoining the actual banks of the river, where, by laborious hand-washing, and the primitive methods of the gold fossicker, a modicum of good stones were found, and when, in 1870, the precious stones were found in greater abundance on the farms, Du Toits Pan and Bultfontein, at a considerable distance from them, the deposit was still thought to be a nalluvial one; for I need hardly mention that up to that time diamond-bearing pipes were unknown, and the world's supply of the precious stones, either from the East or from Brazil, had always been obtained from gem-bearing gravel.

And for a time these new deposits were known as the "Dry Diggings" in contra-distinction to those near the actual river, and they were worked by individual diggers, but it was soon found, not only that they were much richer in diamonds than the river gravel, but that their matrix was neither a gravel nor an alluvial deposit at all. These spots, in short, were the rich mines of the Kimberley of to-day, well-defined volcanic pipes, which have since proved of great depth and importance, and to-day provide the vast bulk of the world's output of diamonds.

Their history does not belong to a paper such as this, and I can only touch upon them. For a time the individual diggers flocked to them, and the River Diggings were almost abandoned, but with the recognition of their enormous value came the gradual elimination of the digger, whose place was taken by syndicates and companies, culminating in the huge combine of to-day.

Meanwhile the squeezed-out digger had drifted back to the banks of the Vaal, and for many years the district in the vicinity of Barkly West was their headquarters. Other small townships sprang into being as the result of "ruches" following the finding of good stones, notably at Windsorton, Hebron, Klipdam, Pniel, Gong-Gong, and dozens of smaller mining camps, but up to 1907 the diggings had practically been confined to Griqualand West. In that year, however, finds in the vicinity of Bloemhof, a considerable distance up-stream, and in the S.W. Transvaal, led to a spread of the diggers in that direction, and in 1910, an extraordinary rush took place to that township, the population of which increased within a few weeks from some 4,000 whites, to nearly 16,000—principally diggers. Finds continued to be made even farther north, and it has been estimated that this diamondiferous area, which extends to Schweizer Rencke, some 35 miles farther north, and to nearly as far east as Klerksdorp, covers an area of some 2,000 square miles.

The principal diggings along the Vaal River, therefore, may be roughly divided into the "Higher" and "Lower" diggings, and may be said to extend from near Klerksdorp in the north, to the Junction of the Vaal and the Orange near Douglas, in the south and for varying distances inland from the banks.

Along this 200 mile stretch of river the gravel, often for miles away from the actual stream of to-day, has been burrowed into as though by an army of gigantic moles; heaps of débris, tailings, and the scrupulously cleaned and graded little pebbles that have been sorted over and over again as "wash," covering the whole of the country, especially in the vicinity of the better-known diggings.

Whilst the permanent river townships, such as Barkly West and others I have enumerated, are the centre of the industry (if it can be called one), it is no uncommon thing for the news of a big find some miles away to cause a rush to that locality to the depletion of the permanent settlements; and these rushes, spasmodic, and seldom resulting in many good finds except those that called them into being, are the scene of the most fevered activity. Tents appear as by magic, wagons, Cape-carts, and all sorts of other vehicles arrive and are used as a living place by their digger owners; stores and "hotels" of the flimsiest description are run up, and these at any rate usually thrive.

In short, a new digging, or a rush back to an old spot long since abandoned (as often happens), is the mining camp of the old days of California, or of Australia, over again. There is, however, but little of the rowdiness that belonged to those days, for the diamond digger is as a rule a most law-abiding person, and the six-shooter is conspicuous by its absence.

The diamonds are sparsely and unevenly distributed in the gravel, and their source remains undiscovered and still somewhat of a mystery. For a time the generally accepted theory was that they had been washed from the Kimberley pipes by the Vaal having at some period flowed through or over, the latter, and then been spread over the country with the gravel by subsequent floods or the changing of the river's course. But this theory has long since proved untenable. There is no evidence that the Vaal ever actually ran through the pipes; and again, not only have the diamond gravels been found far to the north—and up-stream—of any of the Kimberley pipes, but the diamonds found in the gravel are very dissimilar from those of the mines, and easily distinguishable by an experienced eye.

Journal of the Royal Society o Arts, January 21, 1921.

Another theory, and one which appears highly probable, is that at a very remote period, glacial action denuded certain still undiscovered pipes of hundreds of feet of diamond-bearing magma, which, in its slow journey across the country, has been deposited where geological conditions or formation have been favourable, and that subsequent fluvial action has effected still wider distribution, which has culminated near the present river.

Of glacial action there is abundant evidence in the vicinity of the river itself, notably near Windsorton, Hebron, and Pniel. Another theory which has been advanced by certain geologists is that the diamonds were not formed in Kimberlite, but that they have weathered out from a peculiar amygdaloidal diabase, which outcrops in many places on the river bank, and which shows steam vesicles filled with agate, chalcedony, and other forms of silica in nodules—many of which in a loose state are found in the gravel in conjunction with the diamonds. The gravel, whatever its source may have been, presents many features in common; even in spots so widely separated as those of the Higher and Lower Diggings, the deposits near the Harts River in the vicinity of Taungs, those but recently discovered at Rouxville on the Orange River, the huge terraces near the mouth of the Orange (many hundreds of miles from the last-named deposit) and the deposits, so rich in tiny gems, of the sandy coast of what was recently German South-West Africa.

In the vicinity of the Vaal River diggings, the gravel varies in depth from a few inches to as many feet, and this "top" or superficial "wash," which is usually a loose, easily-worked gravel, held together with reddish loamy soil, often covers a distinct stratum of a different gravel; generally consisting of much larger stones, or boulders, often ten or twelve feet in depth, very much more compactly bound together, and usually of a greyish colour. In places this lower deposit becomes practically a conglomerate; the cementing matter being so hardened as to make it extremely difficult to break up. But whether "surface" gravel or "deep" gravel, the smaller water-worn pebbles that go to make up the diamond-bearing portion of it, are always, and everywhere, practically the same.

They are of agate, jasper, nodules of chalcedony, and other forms of silica, fragments of granite, and shale, and above all of banded ironstone, the latter providing the "bandtom" of the digger, an "indication" sought by him everywhere.

The method of searching for the diamonds is, with certain local and unimportant modifications, practically the same on all the diggings. Discarding the primitive and laborious process of hand-sieving and washing, which is rarely used now, except by the very poorest diggers, and which has very little chance of success, the usual procedure is as follows.

The would-be digger, having proved to the satisfaction of the Mining Commissioner and Diggers' Union, that he is a fit and proper person to hold a license, and having obtained both that and a claims licence, pegs out a claim on the chosen spot, which must be part of a "proclaimed" area open to digging. The size of the claims varies somewhat, but they are usually 30ft. square, and the digger is by no means restricted to one; indeed, granted space be available, he can peg out as many as he cares to pay for, provided he works them within a specified time. He usually employs a gang of some six to a dozen natives; these "boys," as they are called, are usually Kaffirs, Xosas, or Basutos, who are to be obtained easily in the neighbourhood of the better-known diggings, especially in the summer season. They are paid a wage which is periodically fixed by the "Diggers' Union," and is usually in the vicinity of £1 per week, in some cases being supplemented by a ration of "mealie-meal."

These men are, many of them, expert diggers, keen-eyed and not always honest, and usually require watching very closely. With picks and shovels the gang, under the supervision of the digger, excavate the gravel down to "bedrock," which may be an actual bottom of shale, or a sandy stratum overlying another layer of gravel. The loosened gravel is "roughed" through screens of large mesh, which reject the larger stones. The boulders are thrown aside, and the resultant finer gravel is then sieved through a rocking machine called a "*bébé*," not as most people believe on account of its fancied resemblance to a cradle, but from the name of the Frenchman Bébé, whose invention it was.

This machine is a long, fine-meshed sieve, some 6ft. or so in length, by about 2ft. in width, slung by chains from a supporting framework, at a slant; the higher end being near the operator. At this upper part provision is made for a jumper sieve to rest, and the mesh of this sieve varies from half-an-inch to perhaps three-quarters. Into this sieve the previously "roughed" gravel is thrown, usually from a bucket, and the operator holding the upper sieve firmly on the *bébé*, rocks the whole backwards and forwards. The fine gravel and sand fall through on to the inclined sieve of the *bébé*, and travel slowly down it, the sand falling through on its way, and only the fine gravel being shot from the lower end on to an evergrowing heap, which forms the "wash" for the next process, while the coarser particles remaining in the jumper, are, after a glance for a possible Cullinan, thrown aside to make place for the next bucketful. The next process, and one which only takes place periodically, and when a large amount of "wash" has been accumulated, is the actual washing by means of a rotary machine.

These machines consist of an iron pan, some 4ft. to 6ft. in diameter, and about 1ft. in depth fixed in an extremely stout wooden framework in which a series of spokes or arms, set with knives, are rotated by a crank. An inclined trough or "feed box" leads to the pan, and into this box the wash is fed, but not in a clean state. Instead, it is mixed with the necessary quantity of sand, or loam, and water, into a mud, the consistency of which is a very vital factor in the ultimate recovery of any diamonds. Once the "wash" is in progress, the mixture is being constantly worked up in the upper end of the feed box, and this work, which is an extremely dirty and unpleasant task, is usually carried on by one or two of the more experienced natives, who convert sand, water, and gravel, into a glorified mud pie, as they feed it into the maw of the constantly rotating knives.

The result of keeping this mixture at a proper consistency is that once the machine is full, the

lighter stones, kept in suspense by the constant rotary movement, run over the edge of the inner portion of the pan, and flow away in a sluggish stream of tailings, only the heavier stones falling to the bottom. A little trap in the lower rim of the pan allows of the residue being occasionally tapped, and it is in this that the diamonds should be found. The final washing and sorting of this residue is an extremely important and delicate task, and is usually carried out by the digger himself. For this process a specially constructed sieve, known as a gravitating sieve, is used, it has an extremely rigid steel mesh, and the proper handling of it is the culminating test of the experienced digger.

Half filling it with the wash from the tap, he holds it quite level and firmly with both hands and rotates it just beneath the surface of the tubs of water, which form an essential part of his equipment, washing away the mud, until in the final water, when the gravel is perfectly clean, he finishes with a peculiar movement, only to be acquired by constant practice, and which has the effect of concentrating the heavier particles into the exact centre of the bottom of the sieve.

Then with an adroit movement he turns the sieve upside down, brings it down with a bang upon the sack-covered sorting table and lifts it, leaving the clean gravel exposed. If the sieve has been properly "thrown," as it is termed, the centre will show a well-defined circle of concentrates much darker in colour than the bulk of the mass, and if the whole series of operations has been properly performed throughout, the diamond should be found amongst these comparatively few little stones.

These dark stones are principally composed of water-worn pebbles, of banded ironstone, already alluded to as "bandtoms," and of approximately the same specific gravity as the diamond, namely, 3·5.

It will thus be seen that the whole system is based upon gravitation, and the gradual elimination of the lighter stones; and although in addition to the rotary washing machines which I have described, there are other mechanical contrivances for washing and treating the gravel (notably the so-called "gravitator"), the principle is practically the same.

The sorting is usually carried out by the digger himself, who after a glance at the little circle of dark bandtoms, carefully scrapes and turns over the stones with a knife or other implement, and this process continues until the whole of the "wash" has passed through the machines and over the sorting table.

But the digger must not be disheartened if days and days of this laborious work ends in the "wash" proving a blank; he may find not only a heavy deposit of the accompanying bandtom, but may be cheered by the presence of garnet, olivine, and ilmenite (called "carbon" by the digger) in his concentrates, but the diamond itself may be absent. Indeed, not only his first "wash" may prove a blank, but the whole of his claim or claims; and yet within a few yards his neighbour may have struck a rich patch and be turning out a small fortune.

For nothing is so uncertain as diamond digging. The distribution of the stones in the gravel is so irregular that the finding of several near together affords no criterion as to the adjoining gravel, and there is no form of mining or digging in which the element of luck plays such an important part.

Small fortunes have been made in a few days by a new chum, have been in some cases picked up on the surface in the shape of a big and valuable stone, without a pick having been put in the claim; and the adjoining digger may be a man grown hoary at the work, who has never found enough to do more than barely pay for the poorest food—indeed he may be, and often is, half-starved. But in the excitement of a big "find" in the vicinity, such as he are forgotten, and he indeed usually forgets his bad luck himself, buoyed up and encouraged by his neighbour's luck, which will be talked of long after he and the rank and file of unlucky ones have been forgotten.

But to return to the process of sorting. Not only has the digger carefully to watch and regulate every process down to the dumping of the sieve on the sorting table, but in the sorting itself he has to be extremely careful. His eye may be gladdened by the sight of a glittering stone, with its facets as bright as though fresh from the cutter, and fully exposed in the centre of the sieve—a triumph to his art as a gravitator—or it may be that the diamond, if present, is oxidised to such an extent as to be unrecognisable except to the eye of an expert; or it may be a splint or a "mackel," or stone of unsymmetrical shape, and be thrown to the outside of the sieve, instead of being in the centre. The eye, tired with the constant attention of hour after hour of such work, can easily miss such stones as these, or in a moment of inattention they may be swept off the table with a handful of worthless gravel. Should, however, a find be made, the diamond, if at all oxidised, is placed in a bottle of hydrofluoric acid and allowed to remain in it during the night, after which it will be found perfectly clean, though it is often by no means bright, but dull and cloudy, until it has ultimately passed through the hands of the cutter.

(To be continued.)

NOTE ON AUGITE FROM VESUVIUS AND ETNA.

By HENRY S. WASHINGTON and H. E. MERWIN.

(Concluded from p. 80.)

On such a hypothesis the formation, either simultaneous or successive, of a granular pyroxenite, composed of closely packed and adherent, anhedral crystals, and free-floating, euhedral crystals, is readily understandable; more readily thus, it seems to me, than on a hypothesis based purely on the influence of gravity. It also serves to explain, as that of gravity does not, such examples of vertical, tubular differentiation as those of Magnet Cove and Mount Johnston, Quebec, which are impliedly regarded by Suess as analogous to "piping" in a steel ingot (Suess, "The Face of the Earth," 1909, iv., 559. Cf. H. S. Washington, *Jour. Geol.*, 1901, ix., 607; F. D. Adams, *Jour. Geol.* 1903, xi., 254).

But we are getting far away from our little augite crystals. Let us pass on to those of a near-by volcano, Etna.

Augite of Monti Rossi, Etna.

The loose crystals of augite that are found in abundance in the ashes and tuffs of Monti Rossi, formed by the eruption of 1669, and elsewhere around Etna, would seem to have been among the first augites to be studied. They were described as early as 1783 by Romé de L'Isle, a few years later by Dolomieu (1788), and by Spallanzani about 1792. It may be of historic interest to cite here Spallanzani's analysis, which seems to have been the first, or among the first, of the analyses of these augites (Spallanzani, "Viaggi alle due Sicilie," (1) chap. vii. (p. 172 of Milan ed., 1825). In a (somewhat pathetic) note referring to the low summation he says: "It must be noted that, apart from the almost unavoidable loss in manipulation, and that of the moisture present in the schorls, the lime is here deprived of the acid with which it was originally provided (combined)."). He found: "free silica 34·5, lime 18·7, iron 7·6, alumina 12·4, magnesia 11·0, sum 84·2." It will be seen that, imperfect as the analysis is from the modern standpoint, Spallanzani determined the presence of all the most essential constituents, and approximately in their relative order of abundance.

Physical characters.—The augite crystals examined were obtained in July, 1914, by Dr. Day and me in the ashes of the western summit of Monti Rossi, near Nicolosi. Though they do not appear to be as abundant as they were in Spallanzani's day, yet a handful was readily collected in half-an-hour.

The habit is the usual one, like that of the crystals of Vesuvius and Stromboli, though they are, on the whole, somewhat smaller, and with a decidedly greater tendency to prismatic development, some of them being three times as long as thick. They are bounded by the planes *a*(100), *b*(010), *m*(110), and *s*($\bar{1}$11). The ordinary contact twins (twinning plane *a*(100)) seem to be rarer than at Vesuvius or Stromboli. They are jet black, and the faces are lustrous, much brighter than those of the Vesuvius crystals, though close examination shows that they are not flat planes, but are as if the crystals were cracked, so that they do not give good reflections for the goniometer. For this reason no crystallographic measurements were made.

In powder or particles under the microscope they are of a greenish-grey colour, without pronounced pleochroism. The refractive index β varied from 1·710 to 1·715; the highest value of γ was 1·735, and the lowest of α was 1·702. Thus the chemical analysis is probably very closely represented by the values:

$$\alpha = 1{\cdot}704, \quad \beta = 1{\cdot}711, \quad \gamma = 1{\cdot}732.$$

The extinction angle is high, but was not determined, as the cleavage is poor and it was not thought worth while to grind a section parallel to *b*(010).

The specific gravity of the crystal fragments used for the analysis, determined with a pycnometer, was 3·373 referred to water at 22°.

Chemical composition.—The loose crystals appear to be very pure, except for patches of a siliceous material (which was readily removed by dilute hydrofluoric acid). Small grains of yellow olivine project from the surfaces, but they are not found in the interior of the crystals. After crushing a batch of crystals to small fragments for analysis, all these olivine particles were carefully removed by repeated search under a binocular, and the material used for analysis is confidently believed to have been free from them. The crystals, however, contain a small amount of minute inclusions of magnetite, which it was impracticable to remove entirely. Treatment with a magnet of about 0·6 g. of the powder analysed showed that this was present to the extent of 3·94 per cent and in column 2 of Table II. the anlysis is corrected for 4 per cent of magnetite.

TABLE II.

	1	2	3	4
SiO_2	47·89	50·09	47·63	47·38
Al_2O_3	3·55	3·71	6·74	5·52
Fe_2O_3	4·17	1·47	n.d.	5·52
FeO	5·98	4·96	11·39	7·89
MgO	13·40	14·01	12·90	15·26
CaO	21·49	22·48	20·87	19·10
Na_2O	0·70	0·73	n.d.	n.d.
K_2O	0·01	0·01	n.d.	n.d.
H_2O+	0·21	0·22	0·29	0·43
TiO_2	2·02	2·11	n.d.	n.d.
MnO	0·20	0·21	0·21	0·10
	99·62	100·00	100·03	99·53
Sp. gr.	3·373		2·886	2·935

1. Augite, Monti Rossi, Etna. Washington analyst.
2. Same, corrected for 4 per cent of magnetite.
3. Augite, Monti Rossi, Etna. S. van Waltersbausen analyst. *Der Etna*, 1880, II, 490.
4. Augite, Monti Rossi, Etna. Rammelsberg analyst. *Pogg. Ann.*, 1858, liii., 436.

Only five or six published analyses of these augites are to be found, and all suffer from the same defects that were pointed out in the case of the Vesuvian augite, that is, non-determination of titanium and alkalies, and, in many, non-separation of the iron oxides.

Discussion.—Any extended discussion of my analysis is unnecessary here, and will be reserved for a future occasion, in connection with those of other Italian augites. It may, however, be of interest to give the composition of the Etna augite in terms of the usual molecules, which is as follows (*No. 1*):—

	1	2
$CaMgSi_2O_6$	70·0	80·1
$CaFeSi_2O_6$	16·5	
$CaSiO_3$	1·5	none
$(Mg,Fe)SiO_3$	none	7·5
$(Mg,Fe)Al_2SiO_6$ ...	7·0	7·0
$Na(Fe,Al)Si_2O_6$ ...	5·0	5·4

It will be seen that the Etna augite (1) is composed very largely of diopside and hedenbergite molecules, with a little wollastonite and acmite, and a small amount of the aluminous Tschermak molecule. In general it much resembles the augite (2) of Stromboli (Kozu and Washington, *Amer. Jour. Sci.*, 1918, xlv., 468), though this carries somewhat less of the diopside molecule, and considerable hypersthene instead of wollastonite. The respective refractive indices are as follows:—

Augite, Etna $\alpha = 1{\cdot}704$, $\beta = 1{\cdot}711$, $\gamma = 1{\cdot}735$.
Augite, Stromboli, $\alpha = 1{\cdot}693$, $\beta = 1{\cdot}699$, $\gamma = 1{\cdot}719$.

This is not the place to discuss the differences, but it may be mentioned that the higher indices of the Etna augite are to be connected with its higher wollasonite and titanium content, which

"Extract of Red Squill (Scilla maritama) as a Rat Poison." By F. W. Smith, B.Sc., A.I.C. After considerable practical experiment with different preparations of various types of squills, the author found that the most effective form of squill rat poison was that prepared in water from an alcoholic extract of the fresh bulb of the red squill (*scilla maritama*), and that salicylic acid may be used as a preservative without fear of hydrolysing the glucoside.

"The Composition of Harrogate Mineral Waters." By William Lowson. The author gives a summary of the analyses carried out in connection with Prof. Smithell's recent general survey of the Harrogate mineral waters, and for comparison a table of analyses dating back some ninety years.

NOTES.

Sir John Cass Technical Institute.—The Annual Prize Distribution was held on Thursday, February 10, when the prizes were distributed by Sir Frederick Black, K.C.B., who subsequently delivered an address on "Liquid Fuel in Peace and War." The Chairman of the Governing Body, the Rev. J. F. Marr, in giving a summary of the work of the Institute during the past session, stated that the total number of students was 1060, a higher figure than in any previous year, and an increase of over 50 per cent on the previous session. An important development of their work they hoped to be able to realise shortly was the initiation of courses of instruction on petroleum technology, adapted to the needs of those already engaged in the industry. They had received very helpful encouragement in connection with this project from representative members of the industry, and it was considered that the Institute was exceptionally well situated for the development of this branch of applied science. In the course of his address, Sir Frederick Black said that whilst the United Kingdom had become an important consuming centre of petroleum products, it was at present only on a comparatively small scale that petroleum, either natural or derived from shale or coal was produced in this country. So far as manufacture or refining was concerned, much more work of that nature was likely to be undertaken at home, and it was probable that home production would also increase. Large British companies interested in oil had their headquarters and distributing agencies here though their wells and refineries were mostly situated in distant countries. The scientific and technical training of men for oil work, geological, chemical, and engineering was already undertaken at such centres as Birmingham University and the Imperial College of Science at South Kensington in particular, where complete courses of instruction were given, similar to those in the mining profession. The Sir John Cass Institute, whilst not expecting to compete with such centres, hoped very shortly to arrange courses of lectures for some of the staff of the oil companies, which should aid them in the efficient discharge of their duties. The Governing Body had prepared a scheme, modest to begin with, but capable of extension, and some of the large oil companies were assisting in working out the scheme and were favourably disposed towards practical help in the cost involved. After briefly describing how the products of petroleum used for fuel were obtained, Sir Frederick proceeded to give a general description of their use in internal combustion engines and for steam raising. If the war had not absolutely discovered any entirely new application of petroleum products, it had enormously developed their use and established their importance on land and sea and in the air. He touched upon the relative advantages of oil and coal for marine purposes, and the methods of handling, and made special reference to the progress in the building of motor-driven ships since the arrival of the "Selandia" in the Thames in 1912 created so much interest. Great attention was being given, not only to the opening up of new sources of supply, but to such important matters as the elimination of waste on the oil fields and in the use of liquid fuels. Oils that admitted of complete refining into such products as motor spirit, lighting and lubricating oils should be so dealt with, in preference to burning the more valuable fractions for steam raising, if a heavier oil not capable of such complete refining could be made available. He hoped that the new work to be undertaken in the Sir John Cass Institute would not be without useful result in respect of some at least of these problems.

The General Report on the Industrial and Economic Situation in Germany in December, 1920, recently issued by the Department of Overseas Trade, was sold out within a few days of publication. A further edition has been printed and the Report (Cmd. 1114) can be obtained, price 9d. (post free 10½d.) on application to H.M. Stationery Office, at the following addresses: Imperial House, Kingsway, London, W.C.2; 28, Abingdon Street, London, S.W.1; 37, Peter Street, Manchester; 1, St. Andrew's Crescent, Cardiff; 23, Forth Street, Edinburgh; or from E. Ponsonby, Ltd., 116, Grafton Street, Dublin.

Under the title "Famous Chemists: the Men and their Work," Messrs. George Routledge & Sons, Ltd., will shortly issue a new work by Sir William Tilden, F.R.S. The volume contains an account of the lives of 21 of the most famous discoverers in chemistry from Robert Boyle to Sir William Ramsay, and will be liberally illustrated. The selection of names has been made in accordance with a definite scheme which is explained in the preface, and the treatment is chiefly biographical. Information has been derived from original sources, some of which have not hitherto been accessible to the English reader. An attempt has been made to give not only a picture of the men and their achievements but also to trace the social and political conditions of the times in which they lived, so as to show something of the relation of discovery in physical science to the progress of civilisation. As it will be entirely free from technicalities, it is hoped that the volume will be acceptable not only to scientific people, but generally to the reading public.

To Detect the Presence of Molybdene.—Some rystals of xanthogenate of potassium and a few rops of strong acid are added to the neutral cold olution. There is then a yellowish colour from ree xanthogenic acid, followed by red and violet. Vith small quantities of molybdene the colour is ed. With large quantities of molybdene, black ily drops are precipitated. Heat prevents re- ction. The reagent can be made with a mixture f carbon sulphide and alcoholic potash, but the olid commercial product keeps well. The oloured product is soluble in ether, amyl acetate nd chloroform. It is preferable to eliminate the alts of Cu, Co, Ni, of ferric iron, of hexavalent r, although the colouration they give is very uch less than that from molybdene. Va_2, Os, UO_3, VO_3, do not impede reaction. Oxalic acid does. hus 5/1000 of a mgrm. of Mo can be detected. *himie et Industrie*, November, 1920.

Alsace.—In a very exhaustive report, M. de etz, technical director-general of the potash ines under sequestration, estimates at 14,000 etric tons of potash salts per diem the tonnage hich can be supplied daily in four or five years y the 17 shafts now being sunk in the Mulhouse asin, if the growth of the staff follows develop- ent of the plant. An annual production of our million tons of sylvinite with 700,000 tons of ure potash would thus be obtained, but the area the prospected deposits will permit of a greater roduction, and there is no doubt that grantees ill not hesitate to sink new shafts.—*L'Engrais.*

Analysis of Ammoniacal Nitrogen in Fertili- ers.—Calcic cyanamide is usually classed nongst ammoniacal fertilisers. From the agri- ultural point of view this is admissible, but not om that of the commercial. In a humid atmos- here cyanamide quickly changes, and then con- ins a large quantity of dicyanamidic nitrogen, d it has been noted that dicyanamide clearly lays nitrification of the ammonia from calcic anamide. It is therefore desirable that the per- ntage of dicyanamide in this product should be little as possible, and it is necessary to be able analyse the percentage of ammonia in a com- ex fertiliser with a base of calcic cyanamide and nmoniacal salts. According to Messrs. Froide- nt and Vandenberghe (*Chimie et Industries*, ovember, 1920) the ordinary process based on stillation in presence of magnesia is not applic- le in this case. They describe another method nployed with success, based upon the action erted by a cold concentrated soda lye and sub- quent disengagement of ammonia. The appara- s consists of a stoppered bottle, 125 cubic cm. capacity, placed in a crystalliser. There are ree necks in the bottle through which a tube ns to the bottom and communicates at the higher rt with a washing bottle containing an aqueous lphuric acid solution to absorb atmospheric nmonia. A tube in the second neck is furnished th a cock to introduce the soda lye. The third be is bent twice and 30 cm. high. The last tube to retain projections of alkaline solution during ssage of air.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

3848—Briscoe, H. V. A.—Separating solids by crystallization from solvents. Feb. 1st.
3742—Duclaux, J.—Treatment of esters. Feb. 1st.
4100—Lindsay Light Co.—Manufacture of thorium compounds. Feb. 3rd.
3949—Soc. l'Air Liquide.—Synthesis of ammonia. Feb. 2nd.

Specification published this Week.

158130—Davis, C. T.—Imperviously covered solid or tablet pharmaceutical or chemical preparation.
141758—Soc. l'Air Liquide.—Processes for the production of hydrogen peroxide.

Abstract Published this Week.

Bichromates.—Mr. R. L. Datta of Calcutta, India, has recently obtained a Patent No. 154810 in this country for an improved method of obtaining bichromates. Sodium and potassium chromates are converted into their respective bichromates by the addition of the corresponding acid sulphate. For example, by adding sufficient potassium hydrogen sulphate in the form of a coarse powder to the hot solution of potassium chromate, all the latter is converted into potassium bichromate. After filtering, the solution is concentrated; when potassium sulphate separates. From the mother liquor after all sulphate is removed, potassium bichromate is obtained by crystallization.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the officia price of 1/- each.

MEETINGS FOR THE WEEK.

Monday, February 28.

Royal Society of Arts, 8.

Tuesday, March 1.

Royal Institution, 3. "Darwin's Theory of Man's Origin" by Prof. Arthur Keith.
Institute of Chemistry. (Annual Meeting).
Röntgen Society, 8.15.

Wednesday, March 2.

Society of Public Analysts, 8. "Acidity of Ink and the action of Bottle Glass on Ink" by C. Ainsworth Mitchell. "Detection of Adulteration in Butter by means of the Melting-Point of the Insoluble Volatile Acids" by George Van B. Gilmour. "Method and Appartus for Routine Determination of Melting Points of Fats and Fatty Acids" by S. H. Blichfeldt and T. Thornley.
Royal Society of Arts, 4.30.

Thursday, March 3.

Royal Society, 4.30. Discussion on "Isotopes," opened by Sir J. J. Thomson. The following also will probably speak:—Mr. F. W. Aston, Prof. F. Soddy, Prof. T. R. Merton and Prof. F. A. Lindemann.
Royal Institution, 3. "Mason Wasps" by F. Balfour Browne.
Chemical Society, 8.

Friday, March 4.

Royal Institution, 9. "Severn Crossings and Tidal Power" by W. A. Tait.
Royal Society of Arts, 8.
Society of Chemical Industry. (At Manchester and Cardiff).

Saturday, March 5.

Royal Institution, 3. "Electricity and Matter" by Sir Ernes Rutherford.

NOTICES.

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THE CHEMICAL NEWS.

VOL. CXXII., No. 3177.

THE THEORY OF AUXILIARY VALENCIES AND "WATER OF CRYSTALLISATION."

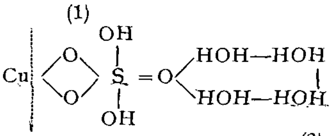
By H. T. F. RHODES.

(Continued from p. 87.)

It is necessary, before proceeding directly to "Conclusions," to make allusion to a paper which had escaped the present author's notice until the time of writing this second part (see J. Macleod Brown, Chemical News, cix., No. 2833, p. 123).

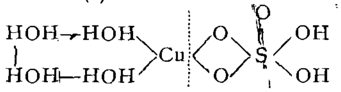
The paper credits copper with quadrivalency, or oxygen with a like valency, and assigns to the quinquehydrate of copper sulphate the structure:

(1)

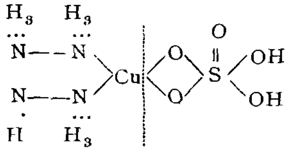


or

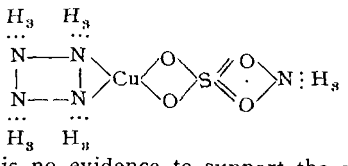
(2)



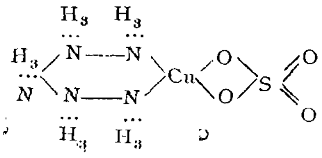
The paper favours formula 2, since in this case the copper ion is more evenly balanced. Formula 1 is substantially in agreement with the author's conclusions except that oxygen *is definitely made* quadrivalent; a conclusion which is certainly allowable and even probable. The paper, however, claims for formula 2 an analogy with quadrammine cupric sulphate to which has been assigned the structure:—



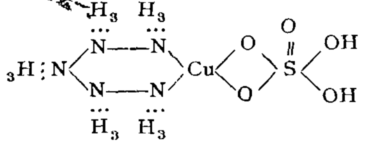
Here a difficulty presents itself, since granting this, to quinqammine cupric sulphate, the following structure must be assigned:—



There is no evidence to support the view that one ammine group is separate from the others; and indeed, its method of hydroxyl substitution step by step is opposed to the idea. *Again it will* be obvious that if the formula

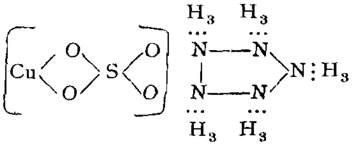


be assumed, a compound of the formula

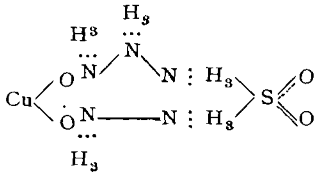


should exist; and no such compound is known. This would seem to be a fair statement of the case for the quadrivalency of copper which, it must be admitted, is not strong.

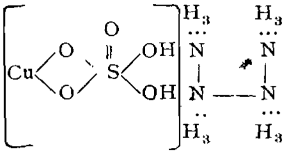
The assumption that the copper atom is mechanically retained within a ring of five NH_3 groups is open to the same objection. It seems necessary to assume, therefore, by a process of eliminiation, the structure:—



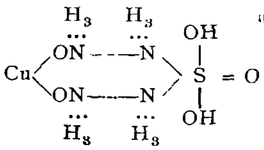
or



That assumes molecular affinity or the quadrivalency of oxygen. Upon this supposition $Cu(NH_3)_4SO_4.H_2O$, becomes:—



or



which is analogous to Formula 1 and β-indirect but strong evidence (if analogy is in this case to be allowed) in favour of these structures either of which would seem to be compatible with the behaviour of the salt on ionisation.

Conclusions.

Werner, by his assumption that the chlorine atom in ammonium chloride was mechanically attached to the nucleus seems to agree with the principle of the earlier theory of Kekulé.

Kekulés theory at least possesses the advantage of simplicity, a simplicity that was destroyed when the term "auxiliary valency" came to be employed, for it has proved increasingly difficult to distinguish between the two kinds of affinity, and now, therefore, it is necessary to assume either that valency must suffice for all, or that recourse must again be had to some theory free of those definitions by which Kekulé's theory has been paralysed.

The disadvantage to Kekulé's hypothesis lies not so much in the theory itself as to its attempted application to compounds that are more easily explained by the law of valency. The application of such a theory to water of crystallisation is reasonable, but its application to ammonium chloride—since nitrogen is known to be quinquevalent in some cases—is unnecessary and absurd The fact that ammonium chloride begins to dissociate at 350° C. does little or nothing to support such a contention; nor can it be adduced as evidence in favour of instability. (It is impossible to judge ammonium salts by a standard to which they are unqualified to conform. It is perhaps undesirable to regard them as "stable" or "unstable," but for our purposes an analogy could justly be sought in such a compound as (SO_2Cl_2). In this sense the ammonium salts are extremely stable. Nor must it be forgotten that at least 15 per cent of ammonium chloride remains undissociated at 1000° C., and that sulphuric acid completely dissociates at 450° C.).

The difficulty of Kekule's theory lay in the fact that it requires the assumption that the affinity increases as the number atoms, and this, of course, is not the case, but by combining it with the heterocyclic theory of valency this difficulty disappears.

At the same time it has to be admitted that in some cases the stability appears to increase as the complexity: the alums are an example:

	M.P.
$Al_2(SO_4)_3(NH_4)_2SO_4.24H_2O$	200°
$Fe_2(SO_4)_3(NH_4)_2SO_4.24H_2O$	230°
$Rh_2(SO_4)_3(NH_4)_2SO_4.24H_2O$	110°

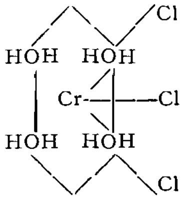
This is admittedly a difficult question and no satisfactory explanation can readily be found. The "gravitational" theory holds, but this increased stability is not true of all salts. The *assumption, on the other hand, that in the alums* this affinity and true valency operate together is not convincing, and is further open to the objection that if the two forms of affinity operate in one case there is no good reason why they should not operate in all. But it seems necessary to assume that some additional force is at work in these cases, and beyond this little can be said.

Space forbids a detailed discussion of a supposed molecular property whose principal claim for consideration lies in the fact that it cannot be confused with valency; but the point that no dogmatic statement is made with regard to it, cannot be too strongly emphasised. It is merely a trial hypothesis that is convenient in its application to some compounds whose powers of valency are doubtful; and if an alternative be necessary, some such theory as that which has been outlined seems advisable in order that confusion may be avoided.

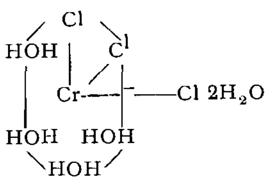
It is desirable to add some remarks with regard to those hydrates which have already been discussed.

$X.6H_2O$.—It has been assumed in the case of magnesium sulphate that the metallic atom is mechanically retained within the ring; so that the interesting question presents itself as to whether it is justifiable to regard the water as being in chemical combination with the salt; and in this case it cannot be denied that the combination is mechanical. But if this general structure is to be allowed, it will not hold for all cases, since two modifications of chromium chloride are known to exist. These can be explained by the inclusion within the ring of chlorine.

α form

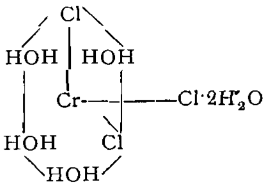


β forms

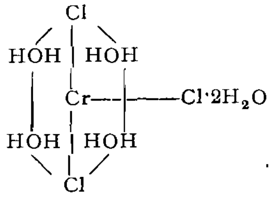


Ortho

β forms



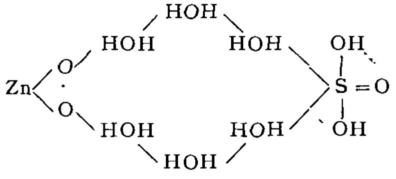
Meta



Para

In the alpha form all the chlorine can be removed by piptation, while in the beta variety but a third. Theoretically three isomers of the beta form are possible, but this does not mean, of course, that they can be isolated. It is known, however, that the alpha salt passes into the beta form when the temperature is elevated, which seems to suggest that the latter is more stable; the formulæ assigned suggest this.

There remains an alternative for those salts that contain seven molecules of water, thus:



If the molecular affinity be disallowed this structure, by analogy with the ammines, seems not improbable. No retardation of the metallic ion appears to have been noticed in the case of zinc or copper; and indeed, Kohlrauch alludes only to the salts of sodium, lithium, barium, and potassium. This question as to the position of the ring is one of interest, and some experimental work is now in progress with a view to arriving at some conclusion with regard to the matter.

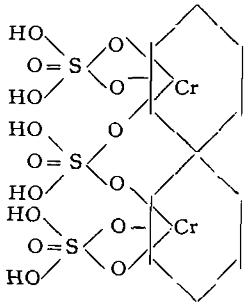
Ephraim and Bolle (*Ber.*, 1915, xlviii, 1770, 1777) appear to have arrived at the conclusion that the stability of some ammines depends not only upon the metal, but also upon the acid group, and their conclusions seem indirectly to support the structure assigned above. This does not mean, of course, that no other conclusion is possible; and, in fact, the explanation advanced by these investigators is different.

Baker (*Proc. Chem. Soc.*, 1909, p. 223) has also assumed that in the case of the ammine that a chain of ammonia molecules divides the anion and cation. Allusion is also made to possible isomerism, apparently of a tautomeric nature, but exactly what is meant does not appear to the present author satisfactorily to emerge.

$X5H_2O$.—These salts have already been fully discussed and further allusion to them seems to be unnecessary.

Bihydrates and terhydrates seem to call for no particular comment, and since there seems no reason for doubting the tervalency of chlorine under some circumstances, the structure assigned is open to no objection.

$X15.H_2O$.—It may here be observed that upon the assumption of a double ring, at least the "ic" sulphates which contain this proportion of water can be classified :—



Conclusion.

No apology is necessary for the ring structure of water, since it has already been advanced, and has at least met with sufficient popularity to be included in some text-books. Its application to those salts that contain six molecules of water seems natural, and it would certainly be difficult to find a more satisfactory explanation; but granting the ring structure in general, the question of "within" and "without" the ring is of great importance. It is probable the position of the ring varies with different salts, but since the aim of this paper has been only the discussion of some general principles, this aspect of the question has not been elaborated, and will ultimately be made the subject of another paper.

The author cannot close without his acknowledgments to those chemists whose papers have been mentioned, and in particular to the excellent paper of Dr. Friend.

CUPROUS OXIDES BY REDUCTION.

By V. V. SARMA.

Cuprous oxide is usually prepared by reduction of an aqueous solution of alkaline cupric salt with glucose. In this process the yellow powder that is first formed, rapidly changes into red cuprous oxide. Yellow cuprous oxide is also precipitated when an alkaline hydroxide is added to a solution of cuprous chloride in hydrochloric acid; but the same transformation into the red variety is effected at once if the solution is hot.

Reference to previous literature shows that the best method for preparing yellow cuprous oxide is by reduction of a cupric salt by means of hydroxylamine in presence of alkali. Also when a copper salt is reduced by Fehling's solution, the character of the precipitated cuprous oxide depends on the proportion of tartrate solution used. With excess of tartrate, red crystalline cuprous oxide is formed, and with little tartrate the cuprous oxide is yellow and amorphous (*J.C.S.*, 1919, Abstracts ii., p. 155).

An attempt was made to prepare yellow cuprous oxide by the ordinary method of reduction of a cupric salt with glucose in presence of an alkali. The reduction was effected at the room temperature, in all cases 25° to 30° C. If the glucose solution is added after the addition of alkali to the solution of the cupric salt, the colour of the precipitated oxide will range from orange to brick-red according to temperature. If the reduction takes place in hot solutions, brick-red precipitates is at once formed. At the room temperature transformation into the red variety takes place slowly.

A slight modification, however, in the method of reduction will produce the yellow oxide. If the glucose solution is first stirred into the cupric salt solution and then the mixture made alkaline with sodium or potassium hydroxide, a rich yellow precipitate without the least tinge of red colour is formed in a short time. Once formed, the yellow cuprous oxide is very stable; the solution may be heated to boiling and the dry substance may be heated to nearly 150° C. without loss of colour.

Experimental.

The yellow precipitate was washed with cold water, dried at 110° C., and percentage of copper determined by (1) oxidation to cupric oxide, and (2) reduction to copper in a current of hydrogen. In (1) 0·6853 grm. of the yellow powder gave 0·7033 grm. of black cupric oxide. This gives 82·02 per cent. of copper in the yellow oxide 0·6322 grm. of the black oxide obtained above gave, on reduction with hydrogen, 0·5062 grm. of copper corresponding to 80·05 per cent of copper, and showing that the yellow powder was completely oxidised to black cupric oxide.

In (2), 0·4736 grm. of the yellow oxide gave, on reduction with hydrogen, 0·3916 grm. of copper, which corresponds to 82·69 per cent of copper in the original substance.

In another experiment the dried yellow product was repeatedly shaken with ether until no change was observed. The ether was removed, and, after drying, the substance was gently heated out of contact with air until it became completely red. 0·4214 grm. of this red oxide gave, after reduction with hydrogen, 0·3728 grm. of copper, corresponding to 88·45 per cent of copper, and showing that the red substance formed is almost pure cuprous oxide.

Conclusion.

The yellow substance formed by reduction of an alkaline cupric salt with glucose does not seem to be pure cuprous oxide. It appears to contain an appreciable amount of cuprous hydroxide which persists even after heating the substance to 110° C. That the yellow substance contains another compound of copper in addition to cuprous oxide is shown by its behaviour towards some common reagents. On boiling it with water, a small portion of it remains suspended in water after the boiling is discontinued, while most of it settles down as a granular powder. The heavier portion is not so bright in colour as the lighter one, and when to this suspended portion a drop or two of dilute sulphuric acid is added, a clear and colourless solution is formed. On adding ammonia, the solution remains colourless but becomes blue on standing, showing that ammoniacal cuprous salt was at first formed. On

adding dilute sulphuric acid to the heavier substance, it behaves in the same way as red cuprous oxide, giving a solution of cupric sulphate and copper.

When the yellow powder is shaken with ether, a small portion of it dissolves in ether, and gives a bluish-green solution. The substance that remains loses its brightness, and becomes dull yellow in colour. When it is gently heated in a test-tube, a thin green coating is formed on the cooler portions of the tube—evidently a portion of the substance that dissolved in ether—and red cuprous oxide remains behind. Ether has no action on red cuprous oxide.

The characteristic behaviour of the yellow oxide indicates that in addition to the 2 to 3 per cent of water that the dried product may contain (*J.C.S.*, 1919, Abstracts ii.), it is mixed with an appreciable amount of cuprous hydroxide. Also conditions of formation being favourable, yellow cuprous oxide is as stable as the red variety up to a pretty high temperature.

Note.—If cane sugar is used instead of glucose, only red cuprous oxide is formed, irrespective of temperature and method of reduction.

Government College Laboratory,
Rajahmundry, South India.
January 15, 1921.

THE ALLUVIAL DIAMONDIFEROUS DEPOSITS OF SOUTH AND SOUTH-WEST AFRICA.*

By FRED. C. CORNELL, O.B.E.

(Continued from p. 90.)

THE digger is bound to keep a register of all diamonds found by him. He can sell them to a licensed diamond buyer on the spot, or may obtain a permit to export them and sell them overseas, or he may obtain a license to hold them himself. He cannot even give them away without a permit, and in such cases the recipent must also obtain a licence to hold them.

But the digger is usually an impecunious being, and his finds are generally sold to a licensed diamond buyer on the spot. The buyers, as a rule, attend the principal diggings periodically, and their advent is generally signalled by the hoisting of a flag at the local hotel, or some such prominent rendezvous.

Here, rooms are set apart for their use, each individual buyer occupying a separate office, where the prospective seller may interview him in privacy. In some of the centres, a row of tiny huts, about the size of bathing boxes, and each well apart from its neighbour, serves the purpose of the visiting buyers, and on their arrival—usually in a body in motor cars—each little hut flies the pennant of some well-known dealer. And the digger can take his choice; he may, if he chooses, go from one to another and try to obtain a better price for his treasure trove than the first dealer has offered him, but as a rule, so good a judge is the average buyer, and so fair is the price he offers, that little good is done by chaffering. And the regular digger soon becomes a customer of one particular firm of buyers. Of course there are exceptional cases, when extraordinarily fine stones have been found, or when the digger—as is occasionally the case—puts a fictitious value upon his hard-earned find. Or, again, there are cases when the buyer is anxious for a particular variety of stone to make up a parcel for Hatton Garden, and when he will pay an exceptional price for the class of stone he needs.

Of course all stones are weighed minutely, as a rule not only by the buyer, but by the digger himself; then again not only size, but colour, shape, and purity are factors in the value of the gems.

With the exception of so-called "fancy" stones, which are stones of a pronounced colour, and are very rare, the most highly-priced diamond is the so-called "blue-white"; a white stone of exceptional purity and with a suggestion of blue in its brilliant and liquid scintillescence. But these are seldom met with, and the digger is well content if his find is of the pure and colourless variety, known as the "Cape White." Many of the larger stones are slightly brownish or yellowish in tint, and these do not command the price of the white stones; though a brilliant canary yellow or an orange coloured stone would command a very high price, as a fancy stone.

The price of diamonds has naturally fluctuated considerably during the long life of the diggings: some twelve years since it was at its lowest ebb, and diggers could hardly dispose of their finds. During this period of depression small white stones of good quality only fetched about 25s. per carat, and the usual poverty of the diggings became terribly accentuated.

To-day, in common with every commodity, the price has gone up, and the same class of stone fetches about £5 or £6 per carat. Against this increase in price, however, there is, of course, the increased price of labour, etc. In addition, a Government tax of 10 per cent. has been levied upon all stones registered; and this impost has hit the digger very hard. In the early days of the diggings, the digger was usually either an old gold prospector from any of the ends of the earth, or one of Kipling's "Legion that never was Listed," a younger son who had been sent out to the Colonies either to "make good" or disappear. Often, as far as the home folks were concerned, he did the latter, reappearing under an entirely different name on the diggings. There are some classical instances of this metamorphosis of young ne'er-do-wells of England, who, partly by luck on the diggings, and partly by push, have become magnates, plutocrats, and even Empire builders, in the country of their adoption. But the average digger has remained a poor man, indeed a very poor man. The possibilities open to the first-comers have long since disappeared. To-day, and indeed from the date of the amalgamation of the mines, his lot has been that of a labourer, a picker up of unconsidered trifles. In sight of him are the mineheads of De Beers, and though he may in his scramble for the crumbs that fall from the rich man's table, occasionally pick up not a crumb, but a plum, his chance of doing so is remote.

Then, again, there is usually a tendency amongst diggers who have struck a rich patch whilst working with a modest gang, immediately to launch out on a larger scale; and expensive machinery and a long wages bill often coincide with bad luck and a long blank, and the embryo "Diamond King" has to sell out at a ruinous cost and begin at the bottom again.

Another favourite ambition of the digger is to try his luck in the actual bed of the present river, which has been found in places to be extremely rich in diamonds. This can only be effected in the dry season when the river is at its lowest. Usually small syndicates are formed by a few of the lucky ones, who have made a little money, and as the river begins to fall, dams, or "breakwaters," as they are termed, are pushed out from the banks to enclose the chosen "pot-hole." This work is expensive, and has to be carried out rapidly, and often before it can be completed, a sudden flood from late rains up-country may have swept it away. Should, however, the enclosure be *completed*, the water is pumped out, and work carried on in the mud and ooze of the actual bed. Work of this description is not only unpleasant, but often dangerous, as the river sometimes rises very rapidly, and in the attempt to save valuable machinery and gear from a rising flood, diggers and their natives have often been swept away and drowned. Still it is only fair to add that many of these "pot-holes" have proved extremely rich, and there are not a few successful men on the diggings who have taken ten or even twenty thousand pounds' worth of stones out of a "breakwater" in the river bed during the few weeks the river has allowed them to work.

There are other methods of working the gravel besides those I have described, for instance, in places a very deep deposit on a rise may be quarried, or "open-faced," as it is termed, and the face thus exposed will often show a number of distinct strata of gravel, apparently deposited at different periods by recurring floods, or by the frequent changing of the river's course in the remote past.

Occasionally these deeper deposits are worked by means of shafts and drives, and the operation is then in the nature of mining.

As the result of good finds in "deep ground" of this nature, or where a very heavy deposit of gravel has been proved over a large area, small companies have from time to time been formed to work the gravel on a large scale; but few of these have been successful, and abandoned buildings, and rusted machinery and gear, can be seen in or near most of the diggings of to-day, a melancholy proof that the Vaal River diggings are a poor man's proposition, and never likely to pay dividends on a large capital. Better luck has attended the large companies such as the New Vaal River Company, the Pniel Company, and others which have taken over very large areas of alluvial, and who sub-let claims to the digger, receiving a certain royalty on all finds. Certain of these companies have large pumping stations of their own, whence the water is conveyed in pipes to parts of the diggings remote from the river, doing away with the laborious pro... "riding" water to the claims ... sorted to on the ordina...

Up to the outbreak o... of the River Diggings... some 3,000 and 5,000 whi... that number of coloured... and the opening up of n... an enormous influx of ne... returned soldiers; indeed, ...ses Government assistance has been given to enable discharged men to make a start at this most precarious of livelihoods. The population is an ever-varying one, men out of employment staking their last few pounds on this gigantic "wheel of fortune," men who have come to try their luck for a week or two, and have remained a life-time, many indeed who have never had luck enough to enable them to get away! And in addition whole families of the "poor white" type, men, women, and children, uneducated, uncouth, and miserably poor, all engaged in the search for diamonds. Unfortunately, poor as is the general luck, the life is a fascinating one, and the saying "Once a digger, always a digger," is a very true one. For men who have had hard luck for years, even if they strike it rich at last, seldom go away; or if they do, drift back again in a very short time. Indeed, the life unfits a man for any other occupation.

In the foregoing description of the diggings I have chosen those of the Vaal River as being the more extensive and better known, and fairly typical of all the others.

There are several smaller alluvial diggings, in the vicinity of the Premier Mine, north of Pretoria, at Mahura Muthla, near Kuruman, on the Harts River near Taungs, and notably on the Orange River near Aliwal North.

Those at Rouxville, near the latter place, have recently produced very fine diamonds, but the principal deposits there are in the hands of a company, and do not call for description here. Suffice to say that the company in question has been a success so far, and has proved that in spite of the failure of similar concerns on the River diggings to which I have alluded, under certain conditions a company or syndicate has a better chance than the individual digger.

Diamonds have also been found near the Orange River at several places down stream, below its juncture with the Vaal, and it may well be that the diggings will eventually spread in this direction. Indeed, at the little known lower portion of this river, which near its mouth runs through an extremely wild and mountainous country, and where it forms the boundary between Little Namaqualand, Cape Province, and the newly-acquired territory recently known as German South-West Africa, there exist colossal terraces consisting of gravels identical with those of the diggings, but very much more highly concentrated. At a spot about fifty miles from the sea, where the river emerges from a series of narrow cañons which has penned it in for some hundreds of miles, and reaches open country again, these terraces have culminated in veritable hills, two or three hundred feet in height, and consisiting of layer after layer of wonderful gravel.

Here the lower strata have become practically ...glomerate bound together with lime, pre... a precisely similar appearance to the very ...posit recently found at Rouxville, fully 800 ...upstream and almost at the opposite side ...h Africa.

...ese huge beds diamonds have been picked ...he natives, but owing to their remoteness ...iculty of access, very little real attempt has been made to test them. Still, owing to the wonderful concentration, these deposits may very possibly some day prove a new and extremely rich source of the diamond.

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I have laid particular stress upon these gravels, as they appear to form a connecting link with the diamondiferous deposits upstream, and those of the recently-discovered deposits on the coast of what was recently German South-West Africa.

These deposits were first discovered in 1907, when the sands of Luderitzbucht, a little desolate seaport on the coast north of the mouth of the Orange were found to be full of small glittering diamonds. At first the story was scoffed at, for there had been a German settlement there since 1884, and no one had ever heard or dreamed of diamonds being there. But diamonds they proved to be, and the deposit at Kolmans Kop, quite close to the settlement of Luderitzbucht, soon proved to be but one of many, indeed they have been proved to exist in varying quantities practically all up the coast from a little north of the Orange River well nigh to Walfish Bay.

The whole coast is a dreary and desolate one, bare sand dunes stretching for many miles inland; it is waterless, and with the exception of Luderitzbucht, was, at the time of the discovery, quite uninhabited—indeed, uninhabitable!

The diamonds, which are very small, and very brilliantly polished by the constant blowing sand, are found in a surface deposit of sand and grit. They are so uniform in size as to give the impression of having been graded, as indeed they apparently have, by the action of both wind and water. And though the main deposits have been found at some small distance inland, rather than on the present beach, there is evidence that the coast line has been gradually rising, and that they came from the sea.

Farther transportation has been effected by the prevailing wind, which blows with great force during most of the year, and is the cause of the shifting sand dunes, which are a feature of the country, and which blows pebbles, grit, sand, and even diamonds impartially.

Of the many deposits located, by far the richest is at Pomona, south of Luderitzbucht, where the lucky first-comers literally filled their pockets with little diamonds. And everywhere along the coast, in close proximity to the diamonds, are found pebbles identical with those of the River Diggings I have described, smaller, it is true, but having undoubtedly a common origin.

And the theory, held by many geologists, is that the diamonds were, in common with gravel, at one time washed down the Orange and into the sea, whence the north-east setting currents have borne them along the coast, and the tides have deposited them where they are found to-day. Another theory is that they have been washed up from a pipe in the sea, but this would not account for the gravel, and it is also a fact worth noting, that the size of the stones is larger near the southern extremity of the fields, near the Orange River, and becomes smaller and smaller at each successive field as one journeys north.

In any case, and whatever their origin, their discovery proved a godsend to the German Administration of the country, which had been a drain upon the Imperial German Government. Rules and regulations were hurriedly framed to control the new source of wealth, prospectors and would-be diggers flocked to Luderitzbucht, where at that time a condensing plant had to supply the only driking water, except that obtained from the ships, and where conditions were as unfavourable either for prospecting or digging as can well be imagined.

In spite of this, and at risk of their lives, men spread up and down the coast, and extraordinary finds were made—many of them to be confiscated by the German officials; and within a month or so of the first finds, the Deutscher Bank in Luderitzbucht had an enamelled bucket three parts full of the precious stones, which had been placed in their keeping pending a decision as to the rightful owners.

To add to the general confusion many claimants for certain valuable portions of the coast now put in an appearance, their claims being generally based upon old concessions granted by natives prior to the taking over of the land by the German Government; and many such claims had never been registered, as the land had always been considered worthless.

In addition to these claimants, several large companies laid claim to the land, others dug up long-forgotten clauses in their charters which gave them a right to "minerals," and in some cases even specified "precious stones should such be found," and in the midst of this confusion new companies were continually being formed. So for a time chaos reigned, during which the licensed prospector was at a great diadvantage, since he never quite knew in pegging a claim whether his title to it would in the end hold good.

And he, as had been the case in Kimberley nearly forty years earlier, gradually disappeared, giving place to various companies, amongst which the better-known, such as Kolmans Kop, and Pomona, had proved, when war broke out in 1914, highly productive. The stones are very small, ranging from one-quarter to an eighth of a carat, but are good quality, and up to August of that year about 5,400,000 carats had been extracted, of an approximate value of nine-and-a-quarter millions sterling. The output was strictly controlled by the German Government, and the sales limited to a little over a million carats annually.

(To be continued)

THE PHYSICAL CHEMISTRY OF BASIC SLAGS.

By CECIL H. DESCH, D.Sc.,
Professor of Metallurgy in the University of Sheffield.

Any account of the physical chemistry of basic slags at the present day must of necessity be largely a confession of ignorance. We are still unaware, in spite of much excellent research work on the subject, of the form in which the principal components are combined in the slag. The chemical analyses indicate the proportions in which the metallic and non-metallic oxides occur, and the sulphur percentage is also known, but there is much difference of opinion as to the nature of the silicates and phosphates which compose the slag, and as to the nature of the sulphides which occur in it as minor constituents. Large and very perfectly formed crystals have been isolated in certain instances, but it is not clear that these are identical with the usual constituents of massive slags, or even that they are mineralogically homogeneous substances. As an illustration of this last point, the case of the large and apparently perfectly formed plates sometimes

found in tap cinder from the puddling process may be mentioned. Microscopical examinations of these plates in transverse sections proves them to be intergrowths of fayalite and ferrous oxide or magnetite, resembling the "colonies" of eutectic in white iron, which also have the appearance of definite crystals, but have been shown by Prof. Benedicks to consist of two constituents, closely intergrown.

The essential components of basic slag are the oxides of iron, manganese, calcium, magnesium, silicon, and phosphorus, whilst sulphides of calcium and manganese, and calcium fluoride, may be regarded as accessory components. Only one state of oxidation need usually be considered, but iron may present itself either in the ferric or ferrous form.

As a starting point, the excellent investigation of acid open hearth slag by Messrs. Whiteley and Hallimond may be taken (J. H. Whitely and A. F. Hallimond, *J. Iron and Steel Inst.*, 1919, i., 199). It is shown by these authors that iron occurs chiefly in the form of the orthosilicate, Fe_2SiO_4, fayalite, with which the corresponding manganese compound, Mn_2SiO_4, tephroite, forms solid solutions. When the proportion of manganese is high, the metasilicate, $MnSiO_3$, rhodonite, is formed, and this may contain some iron in solid solution, but a distinct ferrous metasilicate is not observed. This is confirmed by the present writer's observations of puddling cinders, in which a metasilicate has not been found, even when large proportions of silica are deliberately added. Any such excess appears, both in cinders and in slags, as free silica, usually in the form of tridymite. Excess of iron oxide appears as magnetite, or as solid solutions of similar character, ranging from nearly pure ferrous oxide to crystals richer in ferric iron than magnetite. The growth of such crystals is very characteristic, and they form delicate branched crystallites. In acid slags containing more than 8 per cent of lime, an anorthic metasilicate of calcium, magnesium, iron and manganese is formed, giving to the slag a marked acicular structure. A later paper by the same authors (J. H. Whiteley and A. F. Hallimond, *J. Iron and Steel Inst.*, 1919, ii., 159) shows that eutectics are formed between fayalite and magnetite, and between fayalite and tridymite. The writer has also observed these eutectics, but the further eutectics mentioned by Whiteley and Hallimond, namely, of magnetite and tridymite, and of all three minerals, may perhaps be attributed to imperfect equilibrium. Should they prove to occur in the system in a state of equilibrium, then ferric oxide must be regarded as a separate component.

Leaving aside the question of phosphorus, the basic slags differ from acid slags chiefly in containing a much higher proportion of lime. A glance at the ternary equilibrium diagram for the system lime-magnesia-silica (J. B. Ferguson and H. E. Merwin, *Amer. J. Sci.*, 1919 (iv.), xlviii., 81) will show that a slag containing anything like 40 per cent of lime must be largely made up of the orthosilicate, Ca_2SiO_4. The solid solutions of this silicate with the silicates of other metals are very liable to undercooling, with the formation of glass. Consequently, a glassy ground mass is often observed in basic slags, rendering the interpretation of their constition much more difficult. Acid slags are usually very free from glass, and even puddling cinders mostly contain mere traces of it. Sections of basic slag may exhibit glass in which are embedded small crystals of a phosphoric mineral; and it is evident that the constitution of such specimens could only be determined by making experiments in the direction of annealing, and so permitting the crystallisation of minerals from the glass.

Turning now to the phosphorus, it is remarkable that no phosphate of iron, either ferric or ferrous, is known which is stable at high temperatures. The naturally occurring phosphates are hydrated minerals, and do not yield homogeneous anhydrous products on heating. On the other hand, the phosphates of calcium are well known. Several investigators, however, have shown that silicophosphates are the principal constituents of phosphoric basic slags. The first of these compounds was described by Carnot, who attributed to it the formula $Ca_3(PO_4)_2$, Ca_2SiO_4 (A. Carnot, Richard and Daubre, *Compt. Rend.*, 1883, xcvii., 136). In 1887, Stead and Ridsdale described crystals of a compound also containing phosphate and silicate, $4Ca_3(PO_4)_2$, Ca_3SiO_5 (J. E. Stead and C. H. Ridsdale, *Trans. Chem. Soc.*, 1887, li., 601). Other similar compounds have been described, and their composition is reviewed by Kroll (V. A. Kroll, *J. Iron and Steel Inst.*, 1911, ii., 126), who added yet another, Thomasite, to which he attributed the composition $Ca_3(PO_4)_2$, $3CaO$, Ca_2SiO_4. At an earlier period, Hilgenstock (G. Hilgenstock, *Stahl u. Eisen*, 1883) had described a tetrabasic phosphate, $4CaO$, P_2O_5, and this was long regarded as the essential constituent of all slags which were of agricultural value. It is more likely that the silicophosphates are the valuable compounds. As a rule, these compounds have been described by their external characters only, and very little is known as to their mineralogical individuality. It must be remembered that calcium is replaceable to a greater or less extent in such compounds by iron and other metals, and it is quite possible to find slags, the analysis of which will permit of inclusion under the formula of Thomasite given above. It does not follow that these slags are pure individuals; they may be eutectic intergrowths simulating pure crystals, as mentioned above. When phosphorus is added in moderate quantities to puddling cinders, no new constituent makes its appearance, and phosphorus compounds can evidently pass into solid solution in siliceous iron minerals. The examination of specimens polished on one surface only and etched, as in the examination of metallographic specimens, usually gives much more information than the study of thin sections, although the application of polarised light to the latter affords a useful means of idenifying minerals by their optical properties when their limits have been once defined. The fine eutectics in slags and cinders are generally overlooked in thin sections.

Sulphides enter into solutions to an unknown extent, but a part may remain in insoluble globules. Fluorides combine with phosphates to form minerals of the apatite class, and this, no doubt, accounts for the insolubility, under agricultural conditions, of slags containing fluorspar. Beyond this, little can be stated definitely as to the constitution of the basic slags without further research, the performance of which is highly desirable.—*Transactions of the Faraday Society*, December, 1920.

: USE OF GALLIUM FERROCYANIDE IN ANALYSIS.

By LYMAN E. PORTER and PHILIP E. BROWING.

ɪs been shown that gallium may be separated many elements by precipitation as the ferroide from a solution containing as much as a of its volume of concentrated hydrochloric (Lecocq de Boisbaudran, *Compt. Rend.*, 1882- xciv., 1154, 1228, 1439, 1628; xcv., 157, 410, 1192; 1332; xcvi., 152, 1696, 1838; xcvii., 142, 522, 623, 730, 1463; Browning and Porter, *J. Sci.*, 1917, xliv., 221). Two problems arise nnection with the application of this reaction ıalytical work, namely, filtration and the rery of the gallium from the precipitated salt from iron and the ferrocyanide radical. This r gives the results of a study of these points. e precipitate of gallium ferrocyanide is very inous and, while it is possible to filter it on rdinary paper filter, the filtration is very slow it is difficult to wash the material. The large of the precipitate and the slowness with h it settles make it impossible to decant the d with any success. The effect of changing ıcid concentration and of precipitating the rial in the presence of electrolytes such as sium chloride and ammonium chloride was ed, but it was found that the precipitate does ettle any better under these conditions. Addhe reagent to the hot solution likewise failed ake any appreciable difference in the form e precipitate and in its speed of filtration. rious modifications of paper and asbestos s were tested in an attempt to hasten the tion. The use of asbestos or of paper on a h crucible was found impossible, the precipipassing through even a thick layer of the rial, as it does likewise through paper on a el when suction is applied. If, however, a of fine filter paper fibre, best made by scratchsome paper with a knife, is washed into the el, containing a double filter paper, the ım ferrocyanide is held on it, provided the on is not applied too strongly. If, as is often ase, the first portion of the filtrate is cloudy, ould be poured through the filter again, the ting filtrate being clear. This process can be ed out in much less time than is required for ltration of the same amount of material withhe use of suction. Of two solutions, containequal amounts of the gallium precipitate in :. of liquid, one required 15 minutes to be ed once through a paper filter without suc. whereas the second, by the use of method just described, was completely ed in two minutes, including the second filtraof part of the solution. Table I. shows the ts of the quantitative determination of gal- as the ferrocyanide, the filtration having made with suction. The material was igand weighed as the mixed oxides of gallium ron (*Compt. Rend.*, 1882, xciv., 1228), in the ım ferrocyanide salt, $Ga_4(FeC_6N_6)_3$. If some e iron remains as the carbide, as is probably ase, the resulting weight is not affected, on ınt of the identity of the molecular weights $_2O_3$ and $2FeC_2$ (Treadwell-Hall. "Analytical ıistry," 4th ed., i., 320).

TABLE I.

	Gallium oxide taken. G.	Mixed oxides calculated. G.	Mixed oxides found. G.	Error G.
1.	0·0236	0·0386	0·0400	0·0014
2.	0·0236	0·0386	0·0395	0·0009

This method of direct ignition is not specially recommended, as it gives high results which in small amounts of material show high percentage errors. It was, however, thought best to include it in the general study of the problem.

The recovery of gallium from the ferrocyanide by the ignition with ammonium nitrate and the subsequent separation of the gallium from iron by means of sodium hydroxide has been described by us (Browning and Porter, *loc. cit.*). The possibility of recovering the gallium without the formation of ferric or ferrous salts and the necessity of separating it from these was studied. When the precipitated gallium ferrocyanide is treated with an alkali in solution it is decomposed into the soluble alkali salts of gallium and of ferrocyanide. It was found that when carbon dioxide is bubbled through such a solution to saturation the gallium is quantitatively precipitated as hydroxide, or basic carbonate, in a form easy to filter and readily washed free from ferrocyanide. This behaviour is analogous to the reaction utilised in the detection of the constituents of zinc ferrocyanide (Treadwell-Hall, "Analytical Chemistry," 4th ed., i., 319). Table II. shows some results on the quantitative estimation of gallium after its precipitation as the ferrocyanide and the recovery of the gallium as described above. The ferrocyanide precipitate was in each case filtered on paper after standing for two days. In Expt. 1 the paper with the precipitate was treated directly in a beaker with sodium hydroxide solution and carbon dioxide, the precipitate and paper being filtered off. In Expt. 2. the precipitate was filtered and dissolved off the paper by sodium hydroxide solution and then treated with the carbon dioxide. In the other cases the ferrocyanide was filtered on paper with suction in the presence of paper fibre, dissolved in sodium hydroxide solution and finally precipitated by carbon dioxide from a volume of 100 cc.

TABLE II.

	Ga_2O_3 taken. G.	Ga_2O_3 found G.	Error G.
1.	0·0472	0·0466	—0·0006
2.	0·0236	0·0215	—0·0021
3.	0·0236	0·0225	—0·0011
4.	0·0236	0·0238	+0·0002
5.	0·0944	0·0951	+0·0007
6.	0·1038	0·1035	—0·0003

When an alkaline solution of gallium ferrocyanide is boiled with ammonium chloride a precipitate of gallium is formed, which consists chiefly of the ferrocyanide. If, however, the ferrocyanide is oxidised over to the ferricyanide by hydrogen peroxide in alkaline solution before the ammonium chloride treatment, the precipitate obtained is gallium hydroxide free from any cyanide radicals, as shown by qualitative tests. The oxidation may be made with a nitrate, but the peroxide method is the more satisfactory. This method for the recovery of gallium from the ferrocyanide works well and is rather quicker than the carbon dioxide method. Quantitative results are given in Table III. of some determina-

tions by this method in which the gallium was precipitated as the ferrocyanide and dissolved directly in sodium hydroxide without previous filtration.

Table III.

	Ga_2O_3 taken. G.	Ga_2O_3 found. G.	Error G.
1.	0·0956	0·0952	—0·0004
2.	0·1044	0·1033	—0·0011

Of the elements commonly associated with gallium, whose salts are soluble in alkali, zinc is the most common one that forms an insoluble ferrocyanide. The insolubility of zinc ferricyanide in acid and in ammonium hydroxide makes the separation of gallium from the ferrocyanide by means of the peroxide method impossible if zinc is present. In such a case, however, either of the following two methods may be employed.

In the first case the mixed ferrocyanides are dissolved in sodium hydroxide solution and the bases precipitated together by carbon dioxide. The gallium may now be separated from the zinc by dissolving the precipitate in hydrochloric acid and boiling the solution with ammonium acid sulphite to precipitate the gallium (Porter and Browning, *Jour. Amer Chem. Soc.*, 1919, xli., 1491). The following procedure may also be used. The alkali solution of the ferrocyanides is treated with hydrogen sulphide to precipitate the zinc (Browning and Porter, *loc. cit.*), which even in the presence of the ferrocyanide is precipitated as the sulphide. From the filtrate the gallium may be recovered free from ferrocyanide either by precipitation with carbon dioxide, or by boiling with ammonium chloride after the oxidation of the excess of sulphide and of the ferrocyanide by hydrogen peroxide.

Summary.

1. A method of filtering gallium ferrocyanide with suction has been described.
2. Methods for the recovery of gallium from its ferrocyanide salt by alkali and carbon dioxide by sodium hydroxide, and by hydrogen peroxide and ammonium chloride have been developed.
3. Methods for the recovery of gallium from its ferrocyanide in the presence of zinc have been described.—*Journal of the American Chemical Society*, January, 1921.

THE FARADAY SOCIETY.

General Discussion on "The Failure of Metals Under Internal or Prolonged Stress."

The General Discussion on this subject which is being organised jointly by the Faraday Society, Institution of Mechanical Engineers, Institute of Metals, and the Iron and Steel Institute will take place on Wednesday, April 6 next. There will be both afternoon and evening sessions. The North-East Coast Institution of Engineers and Shipbuilders, The Institution of Engineers and Shipbuilders in Scotland, and the West of Scotland Iron and Steel Institute are also participating in the Discussion.

A preliminary programme has been issued which states that the Discussion will be opened by Dr. W. Rosenhain, F.R.S., who will give a general survey of the subject. Among other contributions on specific aspects of the subject which are expected are:—

"Chemical Influences in the Failure of Metals under Stress." By Prof. C. H. Desch.
"Mechanism of Failure in Metals from Internal Stress." By Dr. W. H. Hatfield.
"The Removal of Internal Stress in Brass." By H. Moore and S. Beckinsdale.
"The Season-Cracking of Brass: Digest of Published Information." By Harold Moore.
"Notes on Fractures in Certain Steel Tubes." By Sir Henry Fowler.
"Intercrystalline Cracking of Mild Steel." By J. A. Jones.
"The Presence of Internal Fractures in Steel Rails and their Relations to the Behaviour of the Material under Service Stresses." By H. S. Rawdon.
"The Spontaneous Cracking of Necks of Small Arm Cartridge Cases." By W. C. Hothersall.
"The Internal Stresses in Brass Tubes." By R. H. N. Vaudrey and W. E. Ballard.
"The Failure of Condenser Tubes." By Commdr. W. Campbell, U.S.N.R.F.
"Note on Corrosion and Season-Cracking." By G. D. Bengough.
"Corrosion Cracking of Non-Ferrous Materials." By W. R. Woodward.
"Stress and Season-Cracking in Cold-Worked Brass Articles." By Dr. F. Rogers.
"Effects of Prolonged Stress on Metals at High Temperatures." By Dr. F. Rogers.
"Internal Stresses in Relation to Microstructure." By J. C. Humfrey.
"Failure of the Lead Sheathing of Telegraph Cables." By L. Archbutt.

Other contributions will probably be made by Prof. C. Benedicks, Mr. W. O. Ellis, Dr. F. C. A. H. Lantsberry, Dr A. McCance, Dr. E. A. Smith, Prof. T. Turner, Mr. J. E. Howard, Dr. F. C. Thompson, Prof. C. H. Matthewson, Dr. R. S. Hutton, Mr. B. S. Haigh, Mr. R. W. Webster.

An exhibition of specimens will be held in connection with the meeting, and those desirous of lending specimens are asked to communicate with Mr. F. S. Spiers, Secretary to the Joint Committee, 10, Essex Street, Strand, W.C.2.

The Action of Water on Wool.—When a small sealed tube, containing woollen threads in water is heated to a temperature of 130°-135° C., the wool undergoes a decrease in volume. The shrinkage, easily noted, corresponds with a profound change in the structure of the wool. The fibres placed between crossed Nicol prisms no longer display the characteristic birefrigency of the primitive wool, and they are also pulverisable dry. The wool can be attacked by water under pressure or by steam; in fact, in the autoclave the same results are observed, but more slowly than with liquid water. With HCl instead of water, results are analogous. Working with a diluted solution of potash (1/20 N for example) the wool shrinks at a lower temperature and at 130° C, disaggregation commences and finally the fibres are completely dissolved.—*Bull. Soc. Chim. de France*, January 20, 1921.

PROCEEDINGS OF SOCIETIES.

PHYSICAL SOCIETY.

Annual General Meeting, February 11, 1921.

PROF. SIR W. H. BRAGG, F.R.S., President, in the Chair.

THE report of the Council was read by the Secretary, Mr. F. E. Smith. The report was unanimously adopted. The report of the Treasurer was read by Mr. W. R. Cooper. The report was unanimously adopted. Votes of thanks to the Honorary Auditors, the Officers and Council, and the Governing Body of the Imperial College were unanimously passed, the respective proposers and seconders being Dr. Chree and Dr. Lister, Mr. Clark and Dr. Borns, Dr. Thomas and Mr. Paul.

The scrutators, after examination of the ballot papers, declared the Officers and Council for the ensuing year to be elected in accordance with the following list:—

President—Prof. Sir W. H. Bragg, C.B.E., M.A., F.R.S. *Vice-Presidents* (who have filled the office of President)—C. Chree, Sc.D., LL.D., F.R.S.; Prof. H. L. Callendar, M.A., LL.D., F.R.S.; Prof. R. B. Clifton, M.A., F.R.S.; Sir Richard Glazebrook, K.C.B., D.Sc., F.R.S.; Sir Oliver J. Lodge, D.Sc., F.R.S.; Prof. C. H. Lees, D.Sc., F.R.S.; Prof. A. W. Reinold, M.A., F.R.S.; Sir Arthur Schuster, Ph.D., Sc.D., F.R.S.; Sir J. J. Thomson, O.M., D.Sc., F.R.S.; Prof. C. Vernon Boys, F.R.S. *Vice-Presidents*—Prof. W. Eccles, D.Sc.; Prof. A. S. Eddington, M.A., M.Sc., F.R.S.; The Rt. Hon. Lord Rayleigh, F.R.S.; Prof. Sir Ernest Rutherford, D.Sc., F.R.S. *Secretaries*—F. E. Smith, O.B.E., F.R.S., National Physical Laboratory, Teddington; D. Owen, B.A., D.Sc., 62, Wellington Road, Bush Hill Park, N. *Foreign Secretary*—Sir Arthur Schuster, Ph.D., Sc.D., F.R.S. *Treasurer*—W. R. Cooper, M.A., B.Sc., 82, Victoria Street, S.W.1. *Librarian*—Prof. A. O. Rankine, D.Sc., Imperial College of Science and Technology. *Other Members of Council*—G. B. Bryan, D.Sc.; C. R. Darling, F.I.C.; Prof. C. L. Fortescue, O.B.E.; E. Griffiths, D.Sc.; F. L. Hopwood, D.Sc.; E. H. Rayner, M.A., D.Sc.; A. Russell, M.A., D.Sc.; T. Smith, B.A.; J. H. Vincent, D.Sc., M.A.; Prof. W. B. Morton, M.A.

After the conclusion of the general business, a discussion on *"Absolute Measurements of Electrical Resistance, and Instruments based on the Temperature-Variation of Resistance"* was held.

SIR RICHARD GLAZEBROOK opened the discussion with a historical review of the work of early workers on absolute resistance measurements and the gradually increasing accuracy which had been obtained in such measurements with the development of improved methods and apparatus.

Mr. F. E. SMITH wished to confine himself to two suggestions. The first was that the accuracy of absolute determinations being now in excess of the accuracy with which the International Mercury Standard could be reproduced, such a standard was now useless, and workers should express their results in true ohms rather than in international ohms. His second suggestion was that teachers should familiarise their students with absolute methods of resistance measurement, and he showed a simple apparatus with which such measurements could be made in the laboratory in a few minutes.

Prof. H. L. CALLENDAR explained the principles of his temperature-compensated resistance bridge, and exhibited various resistance thermometers for special purposes and several instruments for radiation measurements.

Mr. C. R. DARLING described the early work of Siemens on resistance thermometry.

Major TUCKER exhibited and described his hot-wire microphone.

Prof. J. T. MCGREGOR MORRIS exhibited and described a robust and portable hot-wire anemometer.

Miss HARGOOD-ASH, in the absence of Prof. Leonard Hill, exhibited and explained the latter's "Calcometer."

Mr. E. A. GRIFFITHS exhibited and described a resistance gauge for measuring the depth of liquid in a tank.

Mr. A. H. DAVIS read a Paper on *"An Instrument for Measuring Convected Heat."*

Dr. J. S. G. THOMAS exhibited and explained his Directional Hot-wire Anemometer.

Dr. DAYNES, in the absence of Dr. G. A. Shakspear, exhibited and explained the latter's gas permeameter.

Other instruments were exhibited, but owing to the lateness of the hour were not described.

PAPERS RECEIVED.

"Polymerisation amongst Liquids." By W. R. FIELDING, M.A., M.Sc. (Vict.).

A continuation of "Polymerisation in the Solid State" (CHEMICAL NEWS, cxxii., No. 3170). After finding the value of *p* for different elements and compounds, the author makes special reference to water and typical organic compounds, which yield striking results. February 21, 1921.

BOOKS RECEIVED.

"The Extra Pharmacopœia." Vol. I. 17th Edition. By W. H. MARTINDALE, Ph.D., Ph.Ch., F.C.S., and W. W. WESTCOTT, M.B., D.P.H. 1115 pages. Price 27s. net. London: H. K. Lewis & Co.

"Treatise on General and Industrial Chemistry." By Dr. ETTORE MOLINARI. Second Edition, edited by THOMAS H. POPE, B.Sc., F.I.C., A.C.G.I. With 382 illustrations and two Plates. Price £2 2s. London: J. & A. Churchill.

"A Text-book of Inorganic Chemistry for University Students." By J. R. PARTINGTON, M.B.E., D.Sc. Price 25s. net London: Macmillan & Co.

"Introduction to Qualitative Chemical Analysis." By TH. WILHEIM FRESENIUS. 17th edition of the original work, by C. REMIGIUS FRESENIUS, Translated by C. AINSWORTH MITCHELL, M.A. (Oxon.), F.I.C., Editor of the *Analyst.* With 57 Illustrations, xix+954 pages. Price 36s. net. London: J. & A. Churchill.

"A Text-book of Inorganic Chemistry." By J. NEWTON FRIEND, Ph.D., F.I.C. Vol. IX., Part I. Cobalt, Nickel, and the Elements of the Platinum Group. xvii. + 367 Pages. London : Charles Griffin, Ltd.

NOTES.

BRITISH ENGINEERING STANDARDS ASSOCIATION. —A British Standard Specification has been issued by the British Engineering Standards Association for benzol for motor fuel, commonly known as "benzole," a benzene mixture. The specification includes a definition of the term "benzole", a description of the substances and notes on its physical and chemical properties. This is followed by appendices giving necessary tests, including that for the estimation of the sulphur content, with diagram, and the specification concludes with a description and illustration of the standard distillation apparatus. This subject has engaged the activities of the Association for some months past, and the Committee, under the chairmanship of Dr. G. Rudorf, has had the co-operation of the following Government Departments and industrial and scientific organisations : War Office, Air Ministry, H.M. Petroleum Department, National Physical Laboratory, Institution of Automobile Engineers, Institution of Chemistry of Great Britain and Ireland, Association of British Chemical Manufacturers, Auto-Cycle Union, Automobile Association and Motor Union, British Chemical Trade Association, Commercial Motor Users Association, National Benzole Association, Oil and Colour Chemists' Association, Society of British Aircraft Constructors, Society of Chemical Industry. The specification can be obtained from the Secretary of the British Engineering Standards Association, 28, Victoria Street, London, S.W.1., price 1s. 2d., post free.

NOTES AND QUERIES.

ENQUIRY.—Will some correspondent be good enough to recommend some book dealing with the latest practice in preparing steel samples for micro-examination, more particularly the best reagents and methods for differentiating between the various constituents, such as sulphur, phosphorous, slag, silico-sulphide, etc.—STUDENT.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

4895—Armour Fertilizer Works.—Production of aluminium chloride. Feb. 11th.
4556—Attack, F. W.—Condensation of o-benzoyl-benzoic acid or its derivatives. Feb. 9th.
4557—Attack, F. W.—Oxidation of hydrocarbons. Feb. 9th.
4637—Bader, W.—Manufacture of anhydride, etc. Feb. 9th.
4637—British Cellulose & Chemical Manufacturing Co., Ltd.—Manufacture of acetic anhydrides, etc. Feb. 9th.
4642—Cumberland Coal Power & Chemicals Ltd.—Production of hydrogen. Feb. 9th.

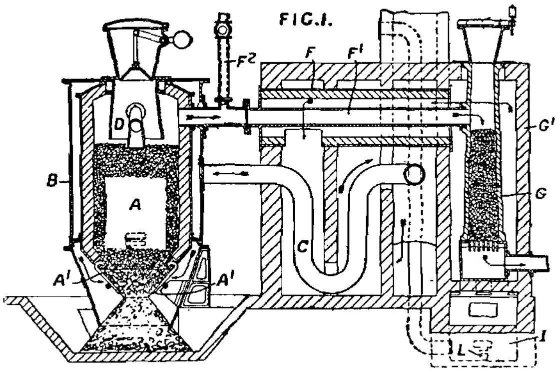
Specification published this Week.

128895—Soc. Industrielle de Products Chimiques.—Separation of the double salt sodium ammonium sulphate into sodium sulphate and ammonium sulphate.
158288—MacLeod, J. G.—Processes for the production of hydrogen sulphide from sulphurous gases.
154170—Terrisse, H. and Levy, M.—Process of and apparatus for regenerating hydrochloric acid used in the manufacture of glucose.

Abstract Published this Week.

Ammonia.—Mr. A. Rollason of Long Eaton, Derbyshire, has been granted a Patent No. 155313 for apparatus for producing Ammonia in which a mixture of air and steam is preheated in a pipe C and a jacket B of a producer A, and is then passed through gates A^1 into the fuel, the level of which is kept constant by a bell D. The temperature in the producer is maintained below 950° C, and the air is wholly deprived of oxygen. The exit gas is cooled to 500° C by a cooler or by steam admitted from a pipe F^2, and is then passed through a tube F^1 surrounded by an outer tube F and is there heated to 550-600° C, by which means it is stated that the molecules of nitrogen are dissociated into atoms. The gas passes from the pipe F^1 through a column G of coke mixed with 5% of limestone maintained by external heating at 700-800° C. Ammonia is produced and is recovered after cooling to 90° C. The remaining gas is introduced into the combustion chamber at L and burnt, the products passing through the casing I to the space between the walls G and G^1 and thence as shown by the arrows.

FIG. I.



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MEETINGS FOR THE WEEK

Monday, March 7.

Royal Institution, 5. (General Meeting).
Royal Society of Arts, 8. "X-Rays and their Industrial Applications" by Major G. W C. Kaye.
Society of Chemical Industry, 8.
Institution of Electrical Engineers, 7. (At Cardiff).

Tuesday, March 8.

Royal Institution, 3. "Darwin's Theory of Man's Origin" by Prof. Arthur Keith.
Society of Chemical Industry. (At Edinburgh).
Institution of Electrical Engineers, 7. (At Leeds, Manchester and Edinburgh).
Institute of Metals, 8. (At Glasgow).

Wednesday, March 9.

Royal Society of Arts, 8.
Institute of Metals, 10.30 and 2.30. (Annual Meeting).

Thursday, March 10.

Royal Institution, 3. "The Meteorology of the Antarctic" by Dr. G. C. Simpson.
Society of Chemical Industry. (At Birmingham).
Institute of Chemistry. (At Liverpool).
Institute of Metals, 10.30 and 2.30 (Annual Meeting).
Institution of Electrical Engineers, 6.
Optical Society, 7.30.

Friday, March 11.

Royal Institution, 9. "Medical Idiosyncrasies" by Dr. J. Freeman.
Physical Society, 5.
Institution of Electrical Engineers, 6.30.

Saturday, March 12.

Royal Institution, 3. "Electricity and Matter" by Sir Ernest Rutherford.

NOTICES.

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THE CHEMICAL NEWS.

VOL. CXXII., No. 3178.

THE COMPOSITION OF DOLOMITES.

By IRENE EVERMAN, O'NEAL MASON and GLENN BROWNING.

THE work on dolomites that has been carried on in the chemical department of Cornell College is still in progress, and the results of some recent analyses are recorded in this paper. We are obtaining specimens from as many different localities as possible, in order to examine the physical as well as the chemical characteristics.

1. Specimen from Le Grand, Iowa.—It is of a buff colour, compact, and somewhat crystalline, with transparent rhombohedral crystals disseminated throughout the specimen.

	Per cent.
SiO_2	1·17
Al_2O_3	0·31
Fe_2O_3	8·75
$MgCO_3$	11·65
$CaCO_3$	78·33
Total	100·21

The specific gravity is 2·64.

The analysis shows a magnesian limestone, rather than a true dolomite.

2. Specimen from near Gouverneur, New York.—It is a mixture of grey and white crystals, resembling ordinary marble.

	Per cent.
SiO_2	0·39
Al_2O_3	2·72
Fe_2O_3	0·17
$CaCO_3$	67·24
$MgCO_3$	29·88
Total	100·40

The specific gravity is 2·94.

The rock approaches a dolomite in composition, but the calcium carbonate too largely predominates for a typical specimen.

3. Specimen from Cape Breton Island. It was kindly sent by the Hon D. Ross MacDonald, to whom we express our thanks.

	Per cent.
SiO_2	5·19
Al_2O_3	2·54
Fe_2O_3	0·41
$CaCO_3$	53·12
$MgCO_3$	38·49
Total	99·75

The specific gravity is 2·83.

The rock approaches a true dolomite in composition.

4. Specimen from Frizington, Cumberland, England.—These are rhombohedral crystals on fluorite, coloured light brown by the presence of iron. The specific gravity was not determined.

	Per cent.
SiO_2	0·47
Al_2O_3	1·10
Fe_2O_3	21·27
$MgCO_3$	25·91
$CaCO_3$	51·05
Total	99·80

The specimen contains a large amount of iron, which replaces a portion of the magnesium, but in other respects it resembles a true dolomite.

5. Specimen from the Marquette District, Michigan. The dolomite as crystals is deposited on a slate-coloured background The botryoidal structure is composed of rhombohedral crystals having a specific gravity of 2·75.

	Per cent.
SiO_2	0·28
Al_2O_3	4·16
Fe_2O_3	0·66
$CaCO_3$	49·83
$MgCO_3$	45·48
Total	100·41

The specimen contains a relatively large amount of magnesium carbonate, and is quite a typical dolomite.

6. Specimen from Tuchshoe, New York.—Traces of iron colour the otherwise white crystals. They are rhombohedral in form, hard, and possess a bright lustre. The specific gravity is 2·84.

	Per cent.
SiO_2	0·45
Al_2O_3	0·16
Fe_2O_3	0·19
$MgCO_3$	46·80
$CaCO_3$	52·16
Total	99·76

The specimen is quite a typical dolomite.

7. Specimen from New Almadin, California —The crystals are white on a grey background. The rhombohedrals are collected in scale-like masses, and are quite brilliant in lustre. The specific gravity is 2·88.

	Per cent.
SiO_2	0·29
Al_2O_3	0·00
Fe_2O_3	5·57
$CaCO_3$	53·41
$MgCO_3$	40·96
Total	99·45

8. Specimen from Providence, Rhode Island.—The rather soft rhombohedral crustals containing traces of visible iron oxide rest on a crystalline base. We could not secure a sufficiently large mass to obtain the specific gravity.

	Per cent.
SiO_2	0·75
Al_2O_3	0·00
Fe_2O_3	2·19
$CaCO_3$	61·50
$MgCO_3$	35·63
Total	100·07

The specimen approaches a true dolomite in composition.

9. Specimen from White Pine, Nevada.—The rhombohedral crystals are white on a brown and grey surface, and are rather soft. The crystals on analysis were found to contain a small amount of copper. We were not able to determine the specific gravity.

	Per cent.
SiO_2	2·16
Al_2O_3	24·24
Fe_2O_3	0·00
$CaCO_3$	72·83
$MgCO_3$	0·31
Cu	0·86
Total	100·40

The specimen is in no sense a dolomite, but a limestone containing only a small amount of magnesium.

10. Specimen from Guanajuato, Mexico.—The specimen is white, with visible traces of iron oxide. The crystals are hard, and hexagonal in form. We were not able to determine the specific gravity.

	Per cent.
SiO_2	86·76
Al_2O_3	4·33
Fe_2O_3	5·50
$MgCO_3$	2·11
$CaCO_3$	0·75
Total	99·45

The specimen is not a dolomite, but quite an ordinary sandstone.

11. Specimen from Nagyrag, Transsylvania.—Rhombohedral crystals on quartz.

	Per cent.
SiO_2	46·33
Al_2O_3	43·28
Fe_2O_3	1·83
$CaCO_3$	2·93
$MgCO_3$	5·05
Total	99·41

The analysis doubtless shows a clay and not a dolomite.

12. Specimen from Clayton, Iowa.—This takes a good polish, when it resembles brown marble. It belongs to the Plattville formation of the Ordovician in the Lower Silurian.

	Per cent.
SiO_2	0·87
Fe_2O_3 and Al_2O_3	1·01
$CaCO_3$	53·34
$MgCO_3$	44·44
Total	99·66

The specific gravity is 2·69. The analysis shows the specimen to be a typical dolomite.

13. Specimen from Dubuque, Iowa.—It is of a grey colour, and quite compact in texture. It belongs to the same geological formation as the preceding.

	Per cent.
SiO_2	7·29
Fe_2O_3 and Al_2O_3	3·00
$CaCO_3$	46·94
$MgCO_3$	42·89
Total	100·12

The specific gravity is 2·83. It is quite a typical dolomite.

Cornell College, Chemical Department.
January, 29, 1921.

THE DETERMINATION OF THE CARBON DIOXIDE IN COAL.*

By F. S. SINNATT, M.B.E., M.Sc. (Tech.), F.I.C., M.I.Min.E.
(Director of Research to the Association) and
W. HARRISON, F.C.S.

Literature.

A CLOSE examination of the literature shows that few results have been published of determinations of the amount of carbon dioxide evolved when coal is treated with acids. One reason for this probably lies in the fact that the ordinary methods for the estimation of carbon dioxide in carbonates are not easy to apply to coal. The amount of carbonates varies within wide limits in different seams, but as a rule is comparatively small.

The information is important for two main reasons: (1) It is not possible to ascertain the percentage of carbon in coal unless that occurring as carbonates, etc. is known. The value obtained in the ordinary method of determining carbon by combustion includes the carbon occurring both in the organic substance and in the carbonates, etc. If the exact percentage of organic carbon in the coal is required, that occurring in the carbonates must be determined, and deducted from the total carbon found by combustion. Certain coals contain up to 5 per cent of substituted calcium carbonates, which is equivalent to approximately 0·5 per cent of carbon. It follows that the percentage of organic carbon in the coal is 0·5 per cent lower than that found by the combustion. This is of some importance when considering the calorific value of coal, as 0·5 per cent of carbon is equivalent to 41·6 calories, or 74·8 B.T.U.'s per pound. In certain abnormal specimens of coal 30 per cent calcium carbonate have been found.

(2) A knowledge of the amount of carbon dioxide occurring as carbonates is also an auxiliary means of obtaining an idea of the composition of the inorganic compounds present in coal. In a later paper, a number of anlyses will be given of the white partings (ankerites) occurring in Lancashire seams. These compounds are fairly constant in composition in a particular seam; if the composition of the ankerites is found by analysis, including the percentage of carbon dioxide present, it is possible to calculate approximately the composition of the particular compound contained in a sample of coal by a simple determination of the carbon dioxide.

The following processes for the determination of carbon dioxide in carbonates are in general use:—

Schroetter's apparatus, and various modifications may be expected to yield results within 1 per cent, when the percentage of carbon dioxide in the compound is high, and at least 1 grm. is available. The method has been found to be useless for the determination of carbon dioxide in coal.

S. H. Collins (*J.S.C.I.*, 1906, xxv., 519) describes an improved form of Scheibler's apparatus, in which the carbon dioxide evolved from carbonates by the action of acids is collected and measured. The method suffers from the inaccuracies inherent in any process where the measurement of small volumes of carbon dioxide are necessary. The equivalence of six sources of error is stated to be 1 per cent.

* Read before the Lancashire & Cheshire Coal Research Association

A method for the determination of small percentages of carbonates in such material as soil is described by Hall & Russell (*J. Chem. Soc.*, 1902, lxxxi., 83), who state that where the amount of calcium dioxide present is only about 0·5 per cent, the whole of the carbon dioxide produced when acid is added may remain dissolved in the reaction products.

The method most generally used is to decompose the carbonates with a suitable acid, and after purifying the carbon dioxide produced, to aspirate it through weighed potash bulbs. Unless the weight of carbon dioxide produced is considerable, the process is quite inaccurate, even when the precaution of counterpoising the potash is adopted; considerable variations in weight of the potash bulbs are possible from external sources.

A number of methods in which standard barium hydrate solution is used for the absorption of carbon dioxide have been described. The general procedure advocated is to place the standard solution in some type of wash bottle, but the process has not been generally adopted, largely for the following reasons:—

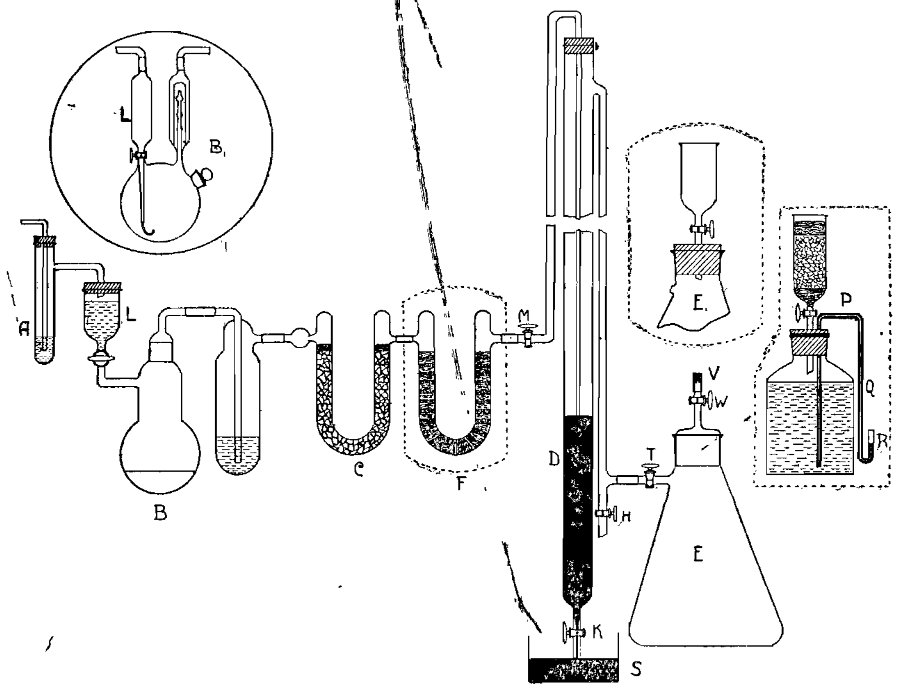
Barium hydrate is only comparatively slightly soluble in water, which necessitates the use of a large volume of solution, and consequently a cumbersome wash bottle; the rate of absorption of carbon dioxide by barium hydrate solution is comparatively low, and consequently a slow stream of gas is essential in order to effect complete absorption. It is difficult, without introducing considerable elaboration to prevent the barium hydrate solution coming into contact with the air, or the breath of the experimenter during the manipulation of the process.

One of us (*Analyst*, 1912, xxxvii., 12) described an apparatus by means of which the rate of flow of a gas into an evacuated vessel could be controlled, and later (*Analyst*, April, 1913) showed that the apparatus could be adopted for the accurate determination of carbon dioxide in carbonates. From the latter paper the following estimations may be quoted, as indicating the degree of accuracy attained by the method:—

Weight of calcite. Grms.		Carbon dioxide found. Grms.		Carbon dioxide calculated. Grms.
0·1310	...	0·0576	...	0·0575
0·1710	...	0·0754	...	0·0751
0·0826	...	0·0364	...	0·0363
0·3490	...	0·1526	...	0·1534
0·0785	...	0·0341	...	0·0345

Apparatus.

The apparatus required is shown in the diagram. (A) Is an efficient wash bottle containing caustic potash solution, which should be renewed frequently. If a rapid flow of air is required it should be supplemented by a second wash bottle. A test should be made to determine the efficiency of the wash bottle; it is essential that the air passing through it should be free from carbon dioxide. (B) Is a decomposition flask as described by Lunge and Machlewski, a Schroetters apparatus or any simple reaction flask. (C) Is a tube containing calcium chloride.



This train of apparatus is all that is required when phosphoric acid is taken to decompose the carbonates in the coal. Phosphoric acid, as suggested by G. S. Morgan (*Proc. Chem. Soc.*, 194, xx., 167) yields results identical with those obtained with hydrochloric acid. When it is thought necessary to use hydrochloric acid, an additional absorption tube (F) must be introduced, containing alternate layers of glass wool and silver

sulphate, in order to eliminate hydrochloric acid. (D) Is a special apparatus (*Analyst*, 1912, xxxvii., 12; *Gas World*, Feb. 22, 1913) the general form of which can be gathered from the diagram. It should not be less than 76 cms. (30in.) in length, and have a diameter of ½in. to 1in., but it should be as small as possible compatible with even working. The inner capillary tube should have an internal diameter of about $\frac{1}{16}$in., and be so arranged as to touch the walls and reach to the bottom of the larger tube. The taps of the apparatus should be well ground. In the reservoir (S) there should be sufficient mercury to fill the large tube. (E) Is an ordinary pressure flask, the capacity of which may be from 1 to 3½ litres (usually 2½ litres). The volume of air available for aspirating through the apparatus depends upon the capacity of this flask. Special flasks have been obtained with a ground stopper to which a funnel was sealed, but the arrangement shown which consists of a broad tube, having the inlet closed with a rubber stopper (V) has been found a most satisfactory method for the introduction of the barium hydrate solution into the flask.

Method of Carrying Out a Determination.

The flask (E) is filled with fresh air and evacuated by means of an ordinary water pump. The carbon dioxide in the flask is reduced to such an amount as to be negligible. If the percentage of carbon dioxide in the air is known accurately, a correction may be applied for the carbon dioxide remaining in the flask. The evacuated flask is now attached to the special apparatus (D) in the manner shown in the drawing, the taps (M), (H), and (K) being closed. The tap (T) is opened, and the tube of the outlet of the apparatus (D) is placed under the surface of the mercury in the reservoir (S). The tap (K) is then opened, and mercury is drawn into the tube (D) until the column is equivalent to the pressure in the evacuated flask; a record of the height of the column is made, and the tap (K) closed.

The sample of coal is pulverised to pass through a 1/90 mesh sieve, and from 0·5 to 5 grms. are introduced into the decomposition flask (B). This is performed most conveniently by weighing the coal on a piece of smooth copper foil and brushing it into the flask with a camel's hair brush. The coal is covered with about twice its volume (5 to 15 cm.) of distilled water, and is then gently heated, the contents being open to the air, until the water commences to boil, and maintained at a gentle simmer for about 20 minutes. By this means the occluded gases present in the coal are expelled. The flask (B) is then assembled, connected to the train of apparatus, and hydrochloric acid (5 per cent) or phosphoric acid (syrupy diluted 4 times) is placed in the cup (L). The acid is allowed to flow into the coal, the tap (K) is now opened, and (M) opened cautiously until air is drawn through the train of apparatus; the decomposition vessel is gently but efficiently agitated. The rate at which the air passes through the apparatus is carefully controlled, and should be kept constant. There is no necessity to alter the tap (M) once the rate at which the air flows through the vessel has been decided upon. After about 10 minutes, the contents of the decomposition flask are gently heated, the temperature being maintained at about 50° C. for half-an-hour. The liquid is then raised to the boil, and kept at this tempereature for an additional 10 minutes. Throughout the whole of this period air is allowed to sweep through the apparatus at the rate of about 2 litres per hour, and any carbon dioxide evolved from the coal is collected in the flask (E). The determination is now complete, and the flow of air is allowed to continue until the train has been completely swept through, or until the pressure in the flask has reached about 70 cms. The tap (T) is then closed, and the flask (E) disconnected. By attaching a freshly evacuated flask, the apparatus is ready for the next estimation.

Determination of the Carbon Dioxide.

The method of determination of the carbon dioxide in the flask by means of standard barium hydrate solution, is that described by Pettenkofer the details of which are described in Lunge's "Gas Analysis," but the following is the exact procedure adopted :—

Preparation and Storage of the Solution of Barium Hydrate.—The barium hydrate solution is prepared by adding 200 grms. of barium hydrate, and 10 grms. of barium chloride to 1 litre of distilled water. After being allowed to settle, 60 ccm. of the clear supernatant liquid are transferred to an apparatus similar to the one shown (P) and diluted to 1 litre with distilled water. This solution must be preserved from contact with the air, and the apparatus shown is convenient for this purpose. The containing bottle is fitted with an outlet syphon tube, having a narrow capillary (Q); this tube is fitted with a short length (2in.) of india-rubber tubing (R). The use of a small capillary obviates the necessity of having to neglect the large volume of liquid which tubes of greater bore contain before the liquid actually contained in the vessel reaches the pipette. It also possesses the advantage that a pinch cock or bead valve is not required on the india-rubber tubing to prevent the liquid flowing out of the vessel; owing to the narrow capillary there is no tendency for either the liquid to be drawn back into the containing bottle or syphon, or out of it. The second hole in the stopper is fitted with a small tap funnel, which contains first a layer of glass wool, and then about 2in. in depth of fresh soda lime. This is covered with a plug of glass wool, and finally the vessel is closed with a rubber stopper containing a single orifice. The barium hydrate solution has been found to keep very well under the above conditions, and no rapid change of titre will be experienced; at the same time it is desirable to carry out a blank determination upon the barium hydrate solution.

Method of Titration.—The tip of the pipette is inserted into the rubber tubing (R), and the required volume of barium hydrate solution drawn off in the ordinary manner. In most of the experiments 50 ccm. were taken for the determination, and when the pipette was filled, the end of it was inserted directly into the rubber stopper (V) of the flask (E). The tap (W) of the flask was then opened gradually, when, owing to its contents being under reduced pressure, the liquid in the pipette is rapidly drawn into the flask. It will be seen that it is possible to repeat these conditions for each succeeding experiment, and as no gas is displaced during the introduction of the barium solution, one of the recognised sources of

error associated with Pettenkofer's method is eliminated. The pipette is removed from the rubber stopper and any traces of barium hydrate remaining behind in the tube are washed into the flask with distilled water. The contents of the flask may then be brought to atmospheric pressure by connecting the outlet to a wash bottle containing caustic potash. The flask is allowed to stand for half-an-hour with occasional agitation; 1 ccm. of phenolphthalein solution (1 part in 250 ccm. of alcohol) is added, and the liquid rapidly titrated with hydrochloric acid (strength N/20 or N/40) until it becomes colourless. The first discharge of the pink colour is taken as the end-point of the titration. Frequently the pink-colour returns, but this should be ignored. Where a large amount of carbon dioxide is present, and a distinct precipitate of barium hydrate is formed, it is desirable to shake the flask vigorously during the titration, in order to remove any barium hydrate which may be entangled (absorbed) in the precipitate.

The difference between the volume of hydrochloric acid required for the actual titration and that of the blank determination is the volume of acid equivalent to the carbon dioxide present in the flask, and consequently in the weight of coal taken for the determination :—

$$2HCl = CO_2.$$

1 ccm. of N/40 HCl = 0·00055 grm. CO_2.

The following shows the amount of carbon dioxide found in certain Lancashire coals, from which the white partings (ankerites) had not been separated :—

Seam	Weight of Coal	Barium hydrate solution ccm	Hydrochloric acid solution N/40. ccm.	Carbon dioxide found grms.	Percentage of carbon dioxide in the Coal.
1. Mountain Mine	5·0	50	9·2	0·0252	0·50
2. Arley	3·0	50	40·2	0·0054	0·18
3. Ravine ...	3·0	50	33·8	0·0107	0·36
4. Abnormal sample, I. ...	1·0	150	38·7	0·0685	6·85
5. Abnormal sample, II.	0·5	175	27·0	0·0916	18·32
6. Pemberton, 2ft.	0·5	50	42·8	0·0036	0·72
7. Garswood, 9ft.	0·5	50	45·8	0·0022	0·44
8. Hoo Cannel	0·5	50	32·4	0·0092	1·84

N/40 HCl (determinations 1 to 6) 1 ccm. = 0·00064 grm. carbon dioxide.

N/40 HCl (determinations 7 and 8) 1 ccm. = 0·000524 grm. carbon dioxide.

Influence of Prolonged Treatment with Water (Bayley and Sinnatt)—If the period of heating the coal with water in order to eliminate the occluded gases is continued beyond 30 minutes, only a slight increase in the amount of carbon dioxide evolved could be detected, thus indicating that the period suggested (30 minutes) is adequate.

Five grms. of coal boiled with 20 ccm. of water for 30 minutes : Carbon dioxide found = 0·09 per cent. Allowed to simmer for 6 hours : Total carbon dioxide found = 0·10 per cent of weight of coal. Amount evolved during last 5½ hours = 0·01 per cent of weight of coal.

The Influence of Using Different Acids (Bayley and Sinnatt).—The following determinations were carried out under identical conditions upon specimens from the same sample of coal, using hydrochloric acid and phosphoric acid. The results indicate that the two acids yield practically identical results by the method previously described.

Five grms. of coal taken in each experiment :—

	Percentage of carbon dioxide. Hydrochloric acid.	Phosphoric acid.
Coal No. 1	0·38	0·38
Coal No. 2	0·27	0·26
Coal No. 3	1·13	1·13
Fusain	0·61	0·56

The above amounts were found when the coal was digested with the acid for three-quarters-of-an-hour. In the case of No. 1 coal the digestion was continued for further periods, with the following results :—

Period of digestion.	Carbon dioxide evolved. Hydrochloric acid.	Phosphoric acid.
First ¾-hour	0·38	0·38
Further 1½ hours	0·06	0·05
Further 4½ hours	0·04	0·04

We wish to place on record our thanks to Miss P. Wray for help during the preparation of this bulletin.

THE ALLUVIAL DIAMONDIFEROUS DEPOSITS OF SOUTH AND SOUTH-WEST AFRICA.*

By FRED. C. CORNELL, O.B.E

(Concluded from p. 102.)

UPON the British occupation of the country in 1915, all prospecting and working for diamonds was forbidden, but at a later date, work on a limited scale was allowed. Meanwhile, the occupation had led to thousands of Union troops being stationed on or near the actual fields, and many of these men planned to return when—as was believed to be likely to happen—the country should be thrown open to prospecting. They, and many a river digger looking for more favoured fields, were however, doomed to disappointment for although upon the assumption of the mandate of the country by the Union Government, the bulk of the new territory was thrown open, the coastal belt containing the diamond fields remained forbidden ground.

And to-day the strip of country stretching from the Orange River to the 26th degree of latitude, and from the coast for 100 kilometres inland, including all the richer mines, has passed under the control of a British combine, who will regulate the output and generally manage diamond matters in South-West Africa.

And although this decision has been an extremely sore point with individual diggers, it is probably the best thing that could have happened. For the country, barren, inhospitable, and waterless, is not fit for the individual with small means, and the indiscriminate granting of licences in such a region would probably have led to a great amount of hardship to the many, and riches but to the few.

In conclusion, I may point out that, although an ardent digger myself, and by no means a pessimist, I do not think that anyone should be encouraged to take up the life as long as he can obtain a livelihood otherwise. Certainly he should never dream of migrating to South Africa

for the purpose of doing so. Unless he be exceptionally lucky, the average digging open to him to-day is likely to swallow up all his little capital, and leave him worse off than he would have been in England. On the other hand, it has been abundantly proved of late that the distribution of the diamond is far more widespread than has been imagined, and systematic prospecting may well disclose new fields of far greater richness than those known at present. The startling discoveries in the sands of Luderitzbucht in 1907, may well find their parallel elsewhere; indeed the extraordinary richness of the newly-discovered fields in Akim on the Gold Coast shows that diamonds are by no means even confined to the regions I have described.

Discussion.

The Chairman (Major Sir Humphrey Leggett, R.E., D.S.O.), said the author had given a most valuable account of what must be one of the most adventurous and dangerous occupations of the world. His description recalled the poet's words, "Hope springs eternal in the human breast," and showed that man would undertake almost any hardship in the hope of reward. It must have been a surprise, he thought, to some of the audience, to hear how many men were engaged in the industry, and that, during a time of rush, the numbers at a township rose by many thousands. The thought had occurred to him that, in the coming and going across unknown land, although but few people might reap the reward for themselves, not only were most valuable discoveries made in connection with diamonds, but other unsought for discoveries resulted. This adventurous groping also had the effect of bringing to the knowledge of the natives of the districts explored, what a white man and white civilisation really were. The behaviour of the white man in out-of-the-way parts was undoubtedly an example for good. The old lurid stories of what occurred in the mining camps were things of the past. Englishmen in the outlying portions of the Empire behaved as Englishmen should do. It was not always borne in mind how much international politics had been affected by exploration and search for diamonds. Sir Harry Wilson, who was present, would remember that in the old days the boundary between the British territory and the old Dutch Republic turned on a question of where the diamond deposits lay. An extraordinary windfall had come to the British Empire in the acquisition of South-West Africa, and there was a possibility of considerable wealth being extracted from the country by systematic company or individual endeavour. He believed it was a fact that 95 per cent of the diamonds of the world were produced within the British Empire, and that had a considerable influence on international exchanges—for example, it would be a serious thing if the people of England wished to buy diamonds and had to purchase them from the United States, instead of the business being in the reverse direction. It seemed to him, however, that the discoveries which were being made day by day by adventurous people were in need of regulation. He understood from the author that the greater part of South-West Africa was now forbidden to the individual, and he thought the author had done wisely in trying to dissuade individuals from adopting the life of a digger. There could be no doubt that the alluvial diamond industry was of great importance to the welfare of South Africa, and probably other portions of the British Empire as well, and that, under regulation and expert guidance, the end of the discoveries of such wealth was nowhere near.

Prof. Ernest H. L. Schwarz, F.G.S. (Rhodes University College, Grahamstown), said the author had very rightly indicated that geologists did not know very much about the origin of diamonds in alluvial deposits. The subject was an exceedingly difficult one. He remembered being shown at the head office of the De Beers Mine in Kimberley a beautiful octahedron over an inch in diameter, which the experts there said undoubtedly came out of one of the mines in Kimberley, but a digger in the river diggings had brought it in to sell. The detectives at Kimberley identified it as a mine stone, but the digger declared emphatically that it was a diamond from the river diggings. The detectives eventually went out to the claim and dug the gravel themselves, from which they obtained the same kind of diamonds. It was difficult to get over evidence of that sort. He believed the author was correct in saying that the river stones were different from those that were obtained from the mines, but cases occurred in which it was difficult to make such a definite statement. It was not known where the alluvial diamonds came from. For some years past he had been getting washings from sandstones of a considerable age, and he very often found diamond splinters in the concentrates, and diamonds were also obtained from the Witwatersrand conglomerate. It was a possible theory that the diamonds found along the Vaal and Orange Rivers did not come from the mines at all, but from a covering of triassic sandstone. The sand might have been blown away, and the heavy concentrates been washed out of the rivers, the gravels thus being obtained. He endorsed the author's advice that nobody should rush out to South Africa and start diamond digging.

Sir Harry Wilson, K.C.M.G., K.B.E., in dealing with the administrative aspect of the river diggings, said that when a large shifting population suddenly assembled in a place in which there was no provision for them, naturally the Government of the country had to take certain measures to provide them with the necessaries of organised life. Such instances occurred on the Vaal River on the borders of the Orange River Colony. He remembered on one occasion travelling to see the diggings not far from Christiana, where there was a large collection of river diggers, and Lady Wilson and himself had two or three very interesting days in visiting the whole community. On that occasion diggings were going on in the bed of the River Vaal, some of them of a very elaborate kind. There were also ordinary diggings in various parts of the gravel, and miniature underground mines were being worked in other places by small syndicates of diggers. He desired to endorse what the author had said about the exceedingly law-abiding character of the population, which, coming as it did from all parts of the Union, was naturally composed of very diverse elements. No trouble was ever experienced with the river diggers, and he thought it might be said

that the Administration did their best in the old Crown Colony days to provide them with certain necessaries, for instance, schools, and inspectors and police. He thought the discovery of diamonds near Rouxville must be quite recent, as he did not remember diamonds being found there during his term of office in South Africa. He would very much like to know with what river system it was connected; he presumed it was the Orange River.

MR. CORNELL said that all the diggings were in the old bed of the Orange River.

SIR HARRY WILSON, continuing, said that two very remarkable discoveries of diamonds occurred while he was in the country, one, the Roberts Victor Mine, and the other the Voerspoed Mine, in the neighbourhood of Kroonstad. There was an interesting story in connection with the first mine. An old Cape farmer of the Eastern Province named Roberts continually dreamed that he was going to find a diamond mine, and so convinced was he that the dream would prove to be true that he sold up his property in the Eastern Province and bought a farm in the neighbourhood of Boshof in the Orange Free States. Instead of farming it, he set to work to try and find a diamond mine, but he did not discover one. He eventually died, but in his will he told his executors that they were to carry on the work he had begun, because he was quite certain there was a mine on the property. One of his executors, now Senator Sir John Fraser, employed the best expert he could obtain to carry on the work, and within three or four weeks of the date of his employment one of the richest mines in South Africa was discovered within a very few yards from where Mr. Roberts had been working. Mrs. Roberts leased her interest in the mine for a comparatively short period for a very large sum of money.

DR. M. HORN (Councillor of State, Belgium), said that although diamonds were widely distributed in the Belgian Congo, the only exploitable deposits so far found were the alluvial diamond fields of the Kasai district in the vicinity of the River Tshikapa. These fields were discovered in 1907, and washings commenced in 1913. The efforts of the Administration were first of all devoted to providing this outlying part of the Colony with means of communication. A road about 95 miles long, suitable for motor lorries and oxen-wagons was now leading from Djoko-Punda, the navigable terminus of the Kasai River, to the diamond fields. The output had risen from 50,000 carats in 1915 to 215,000 carats in 1919. The value of the output of 1920 was estimated at £600,000. On the average, the stones were small, but of good quality; the largest stone yet found weighed about 32 carats. The number of natives at present employed on the "placers" was about 8,000, whilst several thousand more were finding employment in providing housing for the white staff and Government officials, road-making, and other constructional work. The Société Internationale Forestiére et Miniére, a little over half of the capital of which the Belgian Congo Government owned, the remainder being divided equally between some Belgian groups and the American banking group of Guggenheim, controlled the undertaking. In view of the rapidly growing requirements of the district, the import trade of the country would be considerably developed, and it would prove, he hoped, a new market for British industry, and at the same time prove of advantage to the owners of the mines, the natives and the Congo Treasury.

MR. J. L. WILLIAMS said that the discovery of diamonds in Eastern Akim, to which the Lecturer had referred, was made by the Director of Geology to the Government, who, in the course of his peregrinations for the purpose of building up the geological data of the country, panned some gravels which he thought might contain gold, and found diamonds in addition to gold; and as a result of several days' investigation, discovered diamonds in ten different places. Operations had been conducted in various directions, and diamonds had been obtained with a considerable amount of ease, and an alluvial deposit or a shedding or detrition undoubtedly existed. As the Lecturer had seen the diamonds that had come from it, he would be glad to know whether their appearance indicated the probability of the source being more easily discovered than in South Africa. He believed that at Kimberley the surface discovery consisted of high-grade alluvial deposits which afterwards turned out to be detriton from pipes in the locality. Indications were that plenty of diamonds existed in Eastern Akim, and if those concerned with the development could be informed that the appearance of the stones found there indicated something different from those found in South Africa, it would be greatly appreciated.

MR. W. S. LOCKHART, M.Inst.C.E., said he gathered from the paper that the diamonds in German South-West Africa were mostly of very small size, and it would be interesting to know if any large diamonds had been found, and if so, up to what size. He also desired to ask whether, if operations were carried on further away from the coast, stones of a bigger weight might be expected to be found. Did the character of the gravel in German South-West Africa coincide with the river digging gravel, and were the diamonds like those obtained from the river diggings and the mines?

REAR-ADMIRAL J. DE COURCY HAMILTON, M.V.O., in proposing a vote of thanks to Mr. Cornell for his excellent paper and lantern views, said he was glad to know that the diamond-cutting industry had now been introduced into this country and gave employment to a very large number of ex-Service men. Although diamonds were worn mainly by ladies, he imagined from the slides that had been shown that there were no ladies on the diamond fields at all, so at any rate, there was one industry which was left for men exclusively. It was a very fortunate thing that Providence had placed at the disposal of mankind rare metals and stones which were essential to the making of accurate watches, scales, and compasses.

MR. WALTER REID, F.I.C., F.C.S., in seconding the motion, said that if anybody desired to read a book which indicated that Britishers were not yet played out, they should read Mr. Cornell's "The Glamour of Prospecting," which was one of the finest works of the kind that had ever been written. As an old prospector in Brazil, he desired to state that the question of the origin of the gravel in which diamonds were found was of the greatest importance to those connected with the industry. The reference made in the paper

to the glacial origin was, he thought, quite correct. With regard to the question of the whole of the industry being absorbed by one big company, while that company might make a profit out of the undertaking, that was not the way to develop the industry. The statement had been made that in what was formerly German South-West Africa, nobody might dig or prospect for diamonds. He thought that was shutting down an industry which might become extremely valuable to the country. The question was also of importance to the diamond industry itself. An industry was not necessarily improved by raising the prices, and it must also not be forgotten that some very clever chemists were on the track of the the diamond producer. He knew what had been done in connection with the production of diamonds artificially, and he had made artificial diamonds himself, using carbide as the raw material He had been much struck by a notice which appeared in the Press that the Nobel Dynamite Company of Hamburg, were producing diamonds artificially and had made many thousand carats. That might or might not be true, but the artificial diamond industry might grow as the artificial indigo industry grew. Diamond producers ought to bear in mind that the higher they kept the values the better it paid other people to produce diamonds atrificially.

The Chairman, before putting the motion, said it had been hoped that Sir Bernard Oppenheimer, who had just been honoured with a Boronetcy in recognition of his services in introducing the diamond cutting industry into this country, and thereby given employment to a large number of ex-Service men, would have been present at the meeting. He was sure it was the desire of those present that they should record in an informal way their congratulations to Sir Bernard Oppenheimer on the great honour which had been conferred upon him.

The motion was carried unanimously.

Mr. Cornell, in reply, said the reference Prof. Schwarz had made to stones being found on the Vaal River, which the experts declared to be mine stones, although they were not, was typical of what had happened on more than one occasion, but he maintained the statement he had made in the paper was correct—that there was a perceptible difference between diamonds found on the diggings and those found in the mines. One of the former experts of the De Beers Company possessed an almost uncanny sense of the origin of diamonds. He could not only differentiate between diamonds from the diggings but between the diamonds from various mines. He agreed with Sir Harry Wilson's statement that the Administration was to be commended for the way in which it had handled the populations in the diamond districts, particularly in times of rush, when an enormous population would congregate at a particular place within a very short time. He had been much interested in what Dr. Horn had said with regard to the Belgian Congo Data had not been obtainable in regard to Belgian Congo diamonds, and he would very much like to get as much information on the subject as possible. It was not easy to dogmatise with regard to the Akim diamonds after merely seeing them in a parcel, but he had formed the opinion that they were not alluvial diamonds, as the term was understood in South Africa. They must have been found within a very short distance of some plug, vent, or form of matrix in the immediate locality. None of the detritus which had been shown him could be called gravel, and, moreover, the diamonds were of quite a different kind from those found in the deposits of South Africa. The stones found in German South-West Africa were very small; in fact, they appeared almost to have been graded because of their extraordinary similarity one to the other, which was not a feature of the stones found on the Vaal River or any of the other diggings in South Africa. An entrancing feature of the diggings proper was that, while one plot might produce a tiny stone, the next plot might produce one the size of a walnut. The diamonds were irregularly distributed, and very irregular in size, varying from hundreds of carats down to minute stones. The largest stones found at Pomona ranged from four to six to the carat, and were all of excellent quality. Those found at Kolmans Kop were smaller still, and as one went farther north so the size of the stones decreased. It was said that one stone had been found at Pomona which weighed 20 odd carats, but it had never been proved to have come from there. The 5,000,000 carats of diamonds that had been produced in German South-West Africa had scarcely produced a dozen stones of a carat weight each The diamonds were not found in what would be termed gravel, but grit, which had been ground down to the same size as the diamonds found in conjunction with them. With regard to Mr. Lockhart's question as to whether stones of a larger size would be found farther away from the coast, inasmuch as the grading appeared to have taken place by the action of the sea and the wind, and as it was a country in which the whole surface of the ground walked in a storm, it might very conceivably be the case that other deposits of larger stones would eventually be located farther inland. It was not correct, as Admiral Hamilton had inferred, that there were no ladies on the diggings. As a matter of fact, quite a number existed there, and also children, many of the diggers having their wives and families with them. He thought Mr. Walter Reid had missed the point in connection with his remarks that all the diamonds in German South-West Africa were in the hands of a company. He quite agreed that freedom of prospecting was the only possible thing for open countries, but he desired to emphasise that most of German South-West Africa was extremely difficult country. Moreover, not the whole of it was forbidden to the prospector, but only the strip 100 kilometres inland from the sea from the mouth of the river up to the 26th degree. Personally, he was a long way from saying that synthetic diamonds were impossible, but he did not think the average diamond company feared their advent.

Perphosphates and their Industrial Application.—Like persulphates, perphosphates are of two distinct types. (1) Perphosphates obtained by electrolysis of a concentrated solution of bibasic phosphate, which correspond to $P_2O_8H_4$. (2) Perphosphates obtained by the action of concentrated hydrogen peroxide on an acid phosphate, and corresponding to the acid PO_5H_3, analogous with the mono-persulphuric acid of Caro (P. Ammen Schweiz, *Chem. Zeit.*, 1920).—*Chimie et Industrie*, December, 1920.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, February 17, 1921.

Prof. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read :—

"A Comparison of Magnetic Declination Changes at British Observatories." By Dr. C. CHREE, F.R.S.

Field observations of magnetic declination usually aims at supplying not so much the instantaneous value as the mean value appropriate to the place. Unless the observations extend over several days, reference is necessary to the records of a magnetic observatory, and high accuracy is unlikely unless the changes at the field station and the observatory on the day of observation have been closely similar.

The main object of the paper is to investigate the parallelism of declination changes in different parts of the United Kingdom.

A comparison is made of mean monthly, daily, and hourly values as different stations, and of the relative amplitudes of the oscillatory movements which frequently occur on comparatively quiet days. Use is made of magnetic curves from Eskdalemuir, Stonyhurst, Falmouth, and Kew Observatories.

"The Transmission of Electric Waves around the Earth's Surface." By Prof. H. M. MACDONALD, F.R.S.

"The Stability of Fluid Motion." By Prof. T. H. HAVELOCK, F.R.S.

The object of the paper is to illustrate the use of the criterion, introduced by Reynolds and modified by Orr, as a measure of the degree of stability of various fluid motions under different boundary conditions. After a discussion of the method, some cases are examined from this point of view· they include the flow of a stream with a free surface, and flow between fixed planes under different fields of force and boundary conditions of no slip or no tangential stress or constant normal pressure due to the disturbance from the steady state.

"Transformation of Integrals." ByProf. W. H. YOUNG, F.R.S.

"The Constitution of the Alloys of Aluminium, Copper, and Zinc, containing High Percentages of Zinc." By J. L. HAUGHTON, D.Sc., and KATHLEEN E. BINGHAM, M.Sc.

The paper deals with the constitution of aluminium-copper-zinc alloys containing not more than 15 per cent of aluminium and 10 per cent of copper. The investigation has been carried out by the study of the heat absorptions and evolutions which take place in heating and cooling alloys between temperatures at which they are liquid and ordinary temperatures; by the measurement of electrical resistance at various temperatures, and by microscopic study of specimens which have been annealed for prolonged periods and quenched, or which bave been very slowly cooled and quenched.

From the results obtained a model has been constructed to represent the constitution at temperatures above 250° C., and perspective drawings of this model are given in the paper, as well as a series of isothermal sections and sections parallel to the aluminium-zinc face and to the copper-zinc face. A number of typical photomicrographs are shown.

The diagram advanced by Rosenhain and Archbutt has been used as one face of the ternary prism, the other binary system face being somewhat modified from Tafel's diagram. The ternary system contains an eutectic having a composition of Cu 4 per cent, Al 7 per cent, Zn 89 per cent, the temperature at which it forms—378° C.—being only 2° C. lower than that at which the binary aluminium-zinc eutectic is formed. A binary eutectoidal complex is formed between Al_2Zn_3 and the copper-zinc solid solution ϵ. Such a formation is very unusual, if indeed its occurrence elsewhere is known. The line along which this complex is the primary separation from the liquid forms one of the valleys running down to the ternary eutectic; the other two are the depressed aluminium-zinc eutectic and the line separating primary ϵ from primary η,

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FARADAY SOCIETY AND MANCHESTER LITERARY & PHILOSOPHICAL SOCIETY.

A JOINT meeting of the Faraday Society and the Manchester Literary and Philosophical Society was held at Manchester on Friday, February 11, 1921.

Sir Henry A. Miers, M.A., D.Sc., F.R.S., President of the Manchester Literary and Philosophical Society, introduced into the chair Prof. Alfred W. Porter, D.Sc., F.R.S., President of the Faraday Society.

Dr. Allan Ferguson, M.A., opened the discussion with the reading of two papers on "Capillarity."

PART I. *"Some General Considerations, and a Discussion of the Methods of Measuring Interfacial Tensions."*

The importance of accurate measurements of surface tensions, in view of the rapidly accelerating development of colloid physics, is becoming increasingly manifest, and a systematic determination of capillary constants is urgently needed. In this paper are discussed the "genetic" relations of various methods for the measurement of surface tensions. A critical comparison of these shows that among the most promising methods for systematic use are those depending on (1) the measurement of large bubbles or drops; (2) the measurement of the maximum pressure required to release a bubble of air from the end of a capillary tube immersed in the liquid; (3) the measurement of the maximum pull on an anchor ring which is immersed in the liquid and slowly withdrawn therefrom.

Some confusion exists as to the conditions under which the equations for the ascent of a liquid in a capillary tube are valid. By a comparatively simple analysis it is shown that, where a^2 is the specific cohesion and h the height to which the liquid rises in a tube of radius r, the equation

$$2a^2 = rh\left(1 + \frac{1r}{3h} - \cdot 1288\frac{r^2}{h^2}\right)$$

is adequate for all requirements.

Methods are proposed for the measurement of the surface tensions of such liquids as molten metals, and the important problem of the accurate measurement of interfacial tension is discussed.

Part II. "*Modification of the Capillary Tube Method for the Measurement of Surface Tensions.*" By Allan Ferguson, M.A., D.Sc., and P. E. Dowson, M.A.

The capillary rise method for the measurement of surface tensions retains its hold on the affections of experimenters by reason of a somewhat delusive simplicity. In this paper a modification of the method is proposed in which the meniscus is forced down to the end of the capillary immersed vertically in the liquid and the pressure required to effect this is measured on a separate manometer. This simple change sweeps away most of the difficulties attendant on the practice of the ordinary method. Small corrections apart, the difference of level of the surfaces of the liquid in the gauge is equal to the height to which the same liquid would rise in the capillary tube employed. By using a specially light liquid in the gauge, this difference may therefore be magnified. But any manometer of sufficient delicacy may be used, and the use of a catometer avoided. Thus the differential manometer or a simple sloping tube manometer will give accurate results by ordinary naked eye estimations.

Temperature control becomes relatively simple and the temperature of the meniscus may be estimated by means of a thermo-junction placed close to the end of the tube. Calibration of the capillary is unnecessary as measurements are always made with the meniscus in one definite position—at the end of the tube. The following values for the surface tensions of three liquids were obtained by this method:—

Benzene: $T_{15} = 29{\cdot}66$ dyne-cm.$^{-1}$.
Toluene: $T_{15} = 29{\cdot}23$ dyne-cm.$^{-1}$.
Methyl propionate: $T_{15{\cdot}5} = 26{\cdot}09$ dyne-cm.$^{-1}$.

Prof. A. W. Porter, Dr. F. C. Thompson, Mr. Fry, Dr. A. M. Williamson, Dr. R. S. Willows, Prof. W. W. Haldane Gee, Mr. C. E. Stromeyer, and Prof. Arthur Lapworth took part in the discussion.

A number of manometers were exhibited, including a chattock tilting manometer, and a Threlfall micro-manometer, lent for the occasion by the Cambridge and Paul Scientific Instrument Company.

OBITUARY.

PROFESSOR W. ODLING.

The death of Professor W. Odling on February 17, at the advanced age of 92, removes the last of a small party that used for years to meet monthly at Kensington Park Gardens for the "Water" dinner. Crookes, Odling, and Tidy are three names that for many years were associated with the examination of the London Waters. The "Dinners" were of that cosy character that Crookes used to delight in, and Dr. Tidy, who was a splendid talker, kept the party in a state of uproar the whole evening.

On one occasion the writer very distinctly remembers an explosion of gas that took place in the house about five minutes before the dinner hour. The gas engine that in those early days was used to produce the electric light sprung a leak, filled the engine room with gas, and fired it off, wrecking everything in the basement, and smashing all the crockery in the kitchen; but nevertheless the dinner was held with its usual fund of interest and amusement.

It is not generally known that Prof. Odling as well as Prof. Newlands, was one of the pioneers in attempts to devise a scheme of classification of the elements; he published a paper on the "Natural Groupings of the Elements" in 1857.

Prof. Odling succeeded Faraday as Fullerian Professor of Chemistry at the Royal Institution. He was President of the Chemical Society in 1873-74, and of the Institute of Chemistry.

CORRESPONDENCE.

*** The Editor does not accept responsibility for any opinions expressed in this "Correspondence" column. They must in every case be considered as those of the writers.

THE CHEMICAL SOCIETY.

To the Editor of the Chemical News.

Sir,—In April, 1920, a new set of by-laws proposed by the Council of the Chemical Society were ratified at an Extraordinary General Meeting. It will raise, according to circumstances, either a wan smile or a broad grin on the faces of those who recollect that at the meeting the attendance was 39. The membership of the Society is over 3,500, so that the new by-laws have in fact been imposed upon the Society by 1 per cent of the Fellows, the general body having had no say whatever in the matter. It is very high time that this anomaly was rectified. An improvement has, indeed, now been made in the management, the election of Council, and in future, the Fellows will have some say through a neutral body. But the existing Council took care to neutralise this advantage by inventing a by-law which provides that any proposal to change the by-laws of the Society must still run the gauntlet of a meeting in London at which it is never possible for more than a very small minority of the Fellows—and those almost exclusively resident in London—to be present. If such a proposal is lost there it is lost for good. But should it by some miracle win through (a two-thirds majority being necessary), a poll of the members may be called for—a poll action has another chance. There is no provision for a poll in the other case; what is sauce for the chemical goose is not sauce for the gander. The proper course for the Chemical Council to have taken was to arrange for the existing mission of women and for a satisfactory method of electing a Council really representative of the Society, and to leave to that Council the production of new by-laws. It is to be hoped that the provincial Fellows of the Society will be properly impressed by the fact that while they have been graciously accorded an opportunity of recording their votes for members of Council on the ballot papers just issued, they have no voice on the advisability of altering one of the by-laws, although their opinion might just as readily be obtained on the one subject as on the other.—I am, &c.,

University of Glasgow. T. S. Patterson.

MANUFACTURE OF FINE CHEMICALS.

To the Editor of the Chemical News.

SIR,—We, the undersigned, makers of fine chemicals, extended our research and manufacturing plant at the urgent appeal of the State during the tremendous years that followed 1914, in order to secure those essential products of science without which victory could not be attained. The full record of war-time achievements in the sphere of fine chemicals would read like a romance were the full history disclosed. This key industry is now endangered, and unemployment is rife in it, owing to the flood of imports from abroad which, among other circumstances, the present conditions of the Exchanges makes devastatingly possible. We desire to submit to public knowledge the following facts :—

1. The application of chemical science to industry is a necessary factor for the preservation of our world position in commerce. It is also true to say not only that the chemist and the laboratory are in the first line of national defence, but are pivotal in the development of our industrial and commercial resources and wealth.

2. At very considerable cost, essential plant was erected during the war years, and all of it can now be put to peaceful purposes for the continuance in this country of a fine chemical industry not inferior to Germany's. But, under the present unfair economic circumstances, this plant must become idle and useless, unless the State takes measures for its safeguarding.

3. The fine chemical industry, mobilised and expanded in the hour of the nation's needs, provided during the war—to give a few examples—(a) essential medicinal preparations for naval, military, and civilian hospitals; (b) the higher forms of explosives and gases; (c) photographic chemicals for aerial use; (d) research chemicals, without which the development of many new industrial processes would have been impossible.

4. British science is no whit inferior to that of competing nations, nor are British chemical manufactures inferior in quality.

We feel it our bounden public duty to make known to the country the national importance of an industry which is indeed a key to the unlocking of many doors of economic wealth in the future.—We are, &c.,

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[Continued on p. 120

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NOTES.

SOCIETY OF LEATHER TRADES CHEMISTS.—A meeting of the British Section will be held at Leathersellers' Technical College, 176, Tower Bridge Road, London, S.E 1, on Friday, March 18, 1921, at 10.30 a.m. In addition to the official business reports will be given as follows:—"Sole Leather Analysis," by Dr. J. Gordon Parker; "Dressing Leather Analysis," by Mr. P. R. Barker; "Chrome Leather Analysis," by Mr. D. Woodroffe; "Tannin Analysis," by Mr G. E. Knowles; "Sulphonated Oils," by Mr. C. F. Barber; "Limeyard Control," by Mr F. C Thompson. The following Officers of the British Section have been elected for 1921: President—Mr. J. R. Blockey; Vice-President—Mr W. R. Atkin; Hon. Treasurer—Mr. C. D. Wilkinson, "Kingshurst," Great Sankey, nr. Warrington; Hon. Secretary—Mr. S. Hirst, 43, Woodbridge Road, Knowle, Bristol; Members of Committee—Prof. D. McCandlish, Mr. J. T. Wood.

MEETINGS FOR THE WEEK

Monday, March 14.

Royal Society of Arts, 8. "X-Rays and their Industrial Applications" by Major G. W. C. Kaye.
Biochemical Society.

Tuesday, March 15.

Royal Institution, 3. "Darwin's Theory of Man's Origin" by Prof. Arthur Keith.
ustitution of Petroleum Technologists, 5 30.

Wednesday, March 16.

Institution of Electrical Engineers, 5.30. "Effect of Electron emission on the Temperature and Anode of a Thermionic Valve," by Mr. G. Stead, M.A. "On some Thermionic Tube Circuits for Relaying and Measuring" by Miss W. A. Leyshon and Dr. W. H. Eccles.
Royal Society of Arts, 8. "Science and the Investigation of Crime" by C. A. Mitchell.
Royal Microscopical Society, 8.

Thursday, March 17.

Royal Society, 4.30. "Colour of the Light from the Night Sky" by Lord Rayliegh, F.R.S. "Dissipation of Energy in permanent Ocean Currents, with some Relations between Salinites, Temperatures, and Currents" by R. O. Street. "The Vacuum Arc Spectra of Sodium and Potassium" by S Datta, "Heats of Combustion and Formation of Nitro-compounds" by W. E. Garner and C. L. Abernethy. "Catalytic Dehydrogenation of Alcohols" by E. K. Rideal.
Royal Institution, 3. "The Meteorology of the Antarctic" by Dr. G. C. Simpson.
Chemical Society, 4.
Institution of Mining and Metallurgy, 5.30. (Annual Meeting).
Institution of Electrical Engineers, 6. "The Long-distance Telephone System of the United Kingdom" by Sir William Noble.
Society of Chemical Industry. (At Bristol).

Friday, March 11.

Royal Institution, 9. "Researches of a Musical Antiquarian" by Sir Frederick Bridge.
Institute of Metals, 7 30. (At Sheffield).

Saturday, March 19.

Royal Institution, 3. "Electricity and Matter" by Sir Ernest Rutherford.

NOTICES.

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THE CHEMICAL NEWS.

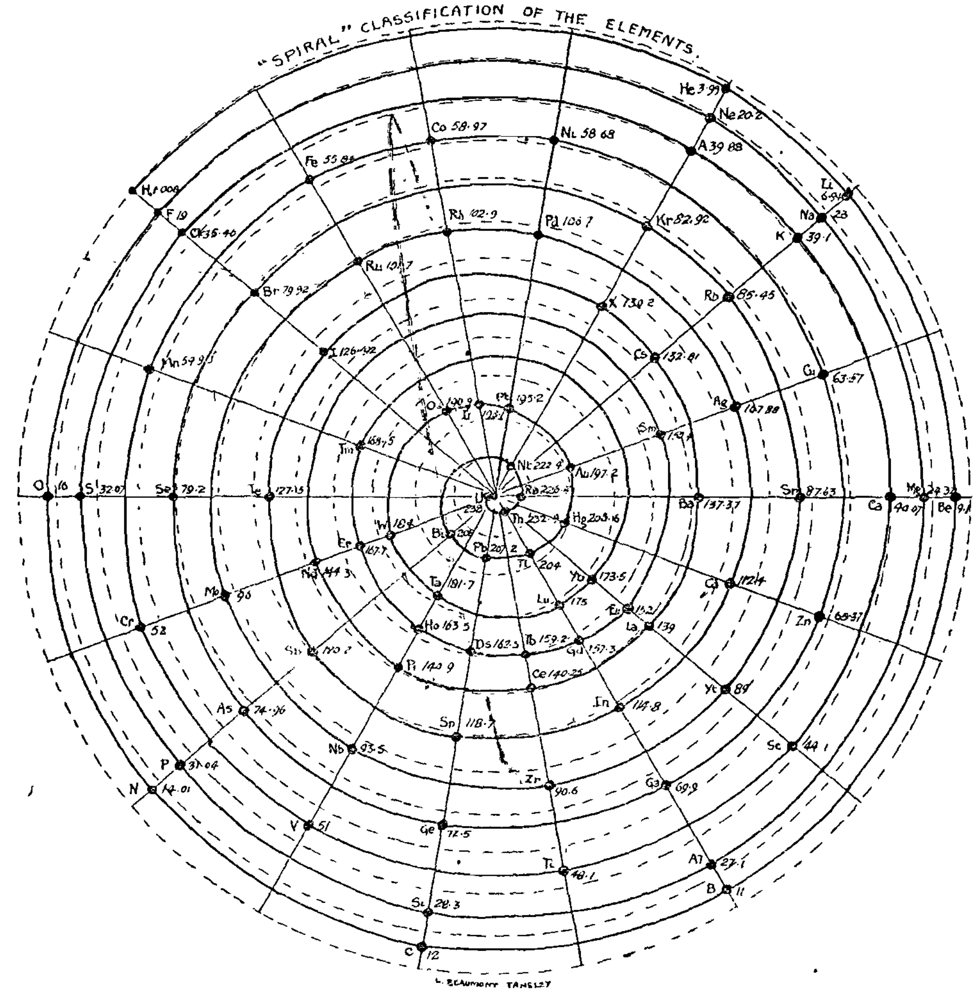
VOL. CXXII., No. 3179.

SPIRAL CLASSIFICATION OF THE ELEMENTS.

By L. BEAUMONT TANSLEY.

THE drawing shows a simple method of tabulating the elements on the same basis as the periodic classification, but in a way which has less of the uninteresting table, and more of the suggestive evolutionary linking, which would make a greater appeal to the young learner of chemistry than the usual *method followed in the textbooks*. Continuity is its aim.

The spiral classification can be easily set out by noticing that the 18 sub-groups are allotted 20° each of the complete circle. Concentric circles of increasing radii can then be drawn to any scale to act as a guide to plotting off the exact values of the atomic weights. An increase of one unit for every ten or twenty units of atomic weight will suffice. Taking the atomic weight of 240 as centre, the elements are then plotted as they decrease in weight, in (say) a counter-clockwise direction, each being placed on a radial line at its correct value, as given in the International List. Commencing with uranium, a practically perfect spiral will then pass through all the elements until hydrogen is reached, this element being placed at the end of the halogens, since to place it at the end of the alkali metal group, where for many reasons it is often shown, would distort the last convolution of a spiral which is certainly more nearly archimedian than logarithmic.



The advantages suggested for this means of classification are:—

1. Each group is given equal importance.
2. The elements of each group, while connected by radials, yet never lack companions on either side with properties to a varying degree akin to their own.
3. The muddling "long and short periods" are dispensed with.

4. The "irregular" elements—iron, cobalt, nickel, ruthenium, rhodium, etc.—usually placed as transition elements, for no very particular reason, in an awkward space apart, here fit in naturally.

5. The beginner at chemistry can see that as the atomic weight decreases the groups near the circumference become far apart in properties and position, and are more easily classified than those of high numbers crowded close together at the centre.

6. The rare earth metals can be included without confusion, and fall together in a small area.

7. Ideas can be suggested as to the breakdown of the radioactive metals in a regular way, and the formation of the lighter elements by degradation can be visualized.

8. The "rogue" elements could be brought into line by drawing the spiral with a larger number of convolutions in the same space so that tellurium could be on its correct radial line, but one convolution nearer the centre than iodine on the halogen radial. It might be imagined that on degradation, one complete twist or oscillation of the parent stock gave tellurium only, but in its right order.

9. A great amount of space is left for new elements.

February 6th, 1921.

AN IMPROVEMENT IN THE NOMENCLATURE OF ORGANIC CHEMISTRY.

By T. SHERLOCK WHEELER, A.R.C.Sc.I., B.Sc., A.I.C.

THAT the nomenclature of organic chemistry is in urgent need of improvement is admitted by all chemists. A uniform system in which the names of all substances are scientifically connected with their formula is lacking. The Genevan system, in which some effort was made to end the existing state of things has found little favour, perhaps because it did not go far enough. The terminations by which it denotes the various classes of substances have, in most cases, absolutely no connection with the characteristic formula of the class, *e.g.*, the ending "al" denotes a compound containing a carbonyl group linked to a terminal carbon; in other words, a member of the so-called aldehydes.

What is needed, however, is not criticism, but improvement. In the hope that those in the forefront of chemistry may be induced to give the subject the attention it deserves, the following suggestions and outline scheme are very tentatively put forward.

Suggestions.

1. An International Congress, on the lines of the Genevan Congress, to be summoned to draw up a scientific system of nomenclature.

2. The Congress to appoint then a permanent International Committee on the lines of the Atomic Weight Committee. The duties of the Committee to be :—

3. To examine all known types of substances and officially name them on the lines laid down by the Congress.

4. To publish a dictionary in the main European languages, giving the old and new names for each class of substance, and each substance where necessary. To render each name mnemonic, the reasons for its adoption to be given in full.

5. The duty of naming substances to include the naming, on a scientific system, of all reactions and phenomena for which a name is considered necessary.

6. To publish a yearly report officially naming each new class of substance and type of phenomenon discovered during the previous year.

7. A certain number of years to be allowed to chemists to become familiar with the new system. After that, any paper not using it to be refused publication in any journal.

8. All matters of doubt to be referred to the Committee.

During the interval, before the system became compulsory, it could be gradually introduced into the textbooks. Anyone ignorant of the present system, and wishing to consult papers in it, could do so by the aid of the official dictionary.

Outline Scheme of Nomenclature.

The following system seeks to connect the name of each substance with its formula on a simple and consistent plan. The names may appear harsh and unfamiliar at first, but use would soon destroy these objections.

General.—Complete saturation is shown by "a," the first vowel. The presence of a double bond is shown by "e," the second vowel. Similarly for "i," the third vowel. Nitrogen, sulphur, and other commonly occurring elements are indicated by their symbols "n," "s," etc., according to the methods described below. Compounds are named either as derivatives of the parent hydrocarbon, or as the derivatives of the parent hydrogen compound of some one element present. Ring compounds and one or two groups are named on a slightly different plan.

Open Chain Hydrocarbons.—The paraffin hydrocarbons are called the "HaC" compounds, the number of carbon atoms being denoted by Greek numerals. Methane is monhac, pentane is penthac. The olefines are the "hec" compounds, acetylenes the "hic" compounds. The alphyl radicals are the "ac" radicals methyl, which is methane minus "H," being monac; ethyl diac and so on. In the same way vinyl, which is ethylene less H, is diec. The numbering of chains for the more complicated compounds is on the Genevan plan of taking the longest chain as the basis, *e.g.*, tetramethyl methane is 2·2-dimonac-trihac.

Halogen Substitution Products of the Hydrocarbons.—They are named on the Genevan plan Ethylidene chloride is 1.1 dichlordihac. Allyl chloride is 1-chlor-2-trihec, or better 1-chlor-2-(e)-trihac.

Alcohols.—Water being the hydro-oxygen corresponding to methane would be "monhao" (or "hao"), and the hydroxy group the "monao" or "ao" radicle. It seems simpler, however, to indicate the hydroxy group by the monosyllable "ho." Ethyl alcohol is then hodihac, allyl alcohol 1-ho-2-(e)-trihac, and alcohols generally the "hohac" compounds.

Ethers.—Since ethers are derived from alcohols by replacing H by an alphyl radical, their names are obtained by replacing the "h" of "ho" by "ac," the radical symbol. Ethyl ether is then diac-o-dihac, methyl-ethyl ether is monocodihac,

and the ethers themselves are the "acohac" compounds. In many compounds it will be noted that the final "-hac" may be dropped without causing ambiguity.

Mercaptans.—Hydrogen sulphide, the sulphur analogen of methane is "monhas," or more simply "has." Ethyl mercaptan is then asdihac, and the mercaptans the "ashac" compounds.

Thio-ethers.—Diethyl sulphide being the ethyl derivative of ethyl mercaptan is diac-as-dihac, and the thio-ethers are the "ac-as-hac" compounds.

Aldehydes and Ketones.—Oxygen doubly linked to carbon is analogous to the monhec, *i.e.,* the methylene radical, and should therefore be called the "monheo" or "heo" radical. It is perhaps more convenient to denote it by "oxy." The aldehydes and ketones are then the "oxy-hac" compounds. Acetaldehyde is oxydihac. Acetone is 2-oxy-trihac.

Acids.—Acids are the 1-1 hydroxy-oxy compounds, *i.e.,* the "1.1 ho-oxy" compounds. The numbers are inserted to show that the groups are attached to the same carbon. Acetic acid is 1-1-ho-oxy-di-hac.

Amines.—Amines are "HaN" compounds, *i.e.,* they are the hydronitrogen compounds. Methyl-ethyl-propyl-amine is monac-diac-triac-han.

Phosphines.—The phosphines are the "hap" compounds.

Hydrazine and Hydrazines.—Hydrazine, the hydro-nitrogen analogous to ethane is "dihan." Methyl hydrazine is "monac-dihan," or "dian-monhac."

Hydoxylamines and Oximes.—Hydroxylamine being analogous to methyl alcohol is "homonhan," or more simply "hohan." $CH_3.NH(OH)$ is "monac-ho-han"; $CH_3.NH.(OCH_3)$ is "monac-monaco-han."

The divalent radical NH being analogous to monhec, *i.e.,* methylene, is "monhen," or, since no ambiguity can arise, is "hen." Acetaldoxime $CH_3CH:NOH$ is then "hohendihac,," acetketoxime $CH_3C(NOH)CH_3$ is "2-(ho-hen)-trihac."

Acid Derivatives.—Acetyl chloride is "1-chlor-1-oxy-dihac." Acetamide is "1-an-1-oxydihac."

Cyanides and Isocyanides.—Cyanides, $N:C.R$ are the "NiC" compounds, "i" because of triple bond. Methyl cyanide is nicmonhac. Isocyanides $C:N.R$ are the "CeN" compounds, "e" because of double bond. Methyl isocyanide is cenmonhac.

Nitro Compounds.—The nitro group is the di-oxy-nitrogen group; it is accordingly called the "di-oxy-en" group. Nitromethane is then monac-dioxyen. In the same way isomitromethane $CH_2:N(OH):O$ is monhec-ho-oxyen, and the isonitro group is the "ho-oxyen" group.

Sulphonic acids.—Similarly the group $.SO_2(OH)$ is the hydroxy-dioxy-sulphur group, *i.e.,* the "ho-dioxy-es" group. Ethyl sulphonic acid is "diac-ho-di-oxyes," ethyl methyl-sulphonate is "monac-diaco-dioxyes," esters being regarded as ether-oxy compounds.

Cyclo-paraffins.—Pentamethylene is r-penthac, "hac" since it is a saturated compound. The cyclo-paraffins are the "r-hac" compounds, "r" as in the Genevan system, indicating "ring." Another method is to look on pentamethylene as a ring-saturated-carbocyclic-fivemembered compound and its systematic name is then r-a-c-pent. Hexa-hydrobenzene is rachex, and the cyclo-paraffins are the "rac" compounds.

Saturated Heterocyclic Rings.—They are named in a similar manner. Piperidine, for example, is r-a-n-hex; ring-saturated-(nitrogen containing)-six-membered.

Unsaturated Rings. — Dihydrobenzene is 1.4.di(e)-ran-hex. As in the Genevan system, the position of the double bond is indicated by the number of the carbon from which it starts. In heterocyclic rings the numbering always begins at the non-carbon element. γ-Pyrone is 4-oxy-(double bonds beginning at 2 and 5)-ring-(oxygen containing)-six-membered, *i.e.,* 4-oxy-2.5.di(e)-rao-hex.

Centric Rings.—A large number of ring compounds which on valency considerations should be written with double bonds do not possess olefinic properties. It seems best, therefore, to write these compounds with a centric formula, and to read their characteristic properties into that formula, just as we read olefinic properties into a double bond. The names of these compounds are formed by prefixing "c" to the name of the corresponding saturated ring compound. Benzene is c-r-a-c-hex, *i.e.,* centric-ring-saturated-carbo-cyclic-six-membered. Centric compounds, since they do not form addition compounds easily, may be considered as saturated. Pyridene is c-r-a-n-hex, centric-ring-saturated-nitrogen-containing-six-membered. Pyrrol, which may also be written with a centric formula is cranpent. Thio-phene, the sulphur analogue of pyrrol, is in a the centric system is a bi-centric-ring-saturated-sulphur-five-membered. Naphthalene, which on the centric system is a bi-centric-ring-saturated-carbocyclic-ten-membered compound, is then bi-c-r-a-c-dec. The Latin numeral is used to avoid ambiguity. Anthracene may be regarded as a tercentric fourteen-membered ring compound. It is therefore called ter-crac-tetradec. Indole is a bicentric nine-membered ring containing one nitrogen atom, and is thus 2-bi-cran-non. The "2" indicates the position of one of the carbons common to the two centres. It is unnecessary to specify the other common carbon, since in nearly all compounds it is in the so-called ortho position to the indicated one. The numbering, it is to be noted, is always clock-wise, but non-adherence to this rule seldom causes ambiguity. Heterocyclic rings containing more than one non-carbon element are named from what may be called the present heterocyclic ring, *i.e.,* the ring containing only one non-carbon element; pyrazole, for example, is 2-N-c-r-a-n pent:—2-nitrogen-centric-ring-saturated-nitrogen-five-membered, the numbering, as usual, beginning at the non-carbon element incorporated in the name.

Benzene Derivatives.—As the radical system need never be used in naming the compounds of the above ring systems, benzene excepted, it is not necessary to add "hac" to their names to obtain "ac" for the corresponding radical. In the case of benzene, phenyl could be called crachexac, but it is more convenient to abstract the "h" from the "hex" and to call phenyl "cracex." Benzene derivatives are then named on the same plan as alphyl derivatives; toluene is monac-crachex, and the aromatic hydrocarbons the ac-crahex compounds; phenol is ho-crahex, aniline is cracex-han. As an example of a complicated derivative, *p*-rosaniline $C(C_6H_4(NH_2)1.4)_3OH$ is

tri(4.an.cracex).ho.monhac.

Phenomena and Reactions.—Tautomerism might be shown by writing the name of the tautomer present in the larger quantity, followed by "t" and an indication of the changes brought about by the link changing. Aceto-acetic ester would be 4monaco.2.4-dioxy-tetrhac-t-[2.(e).2-ho]. The word corresponding to keto-enol is oxy-eho. A better name than tautomerism could no doubt be found for the whole phenomenon. As to the naming of reactions, the Claisen condensation might be called the "oxy-hac" condensation, since hydrocarbon compounds containing an oxy group always take part. Other reactions could be named on similar lines. Terms such as condensation would of course require precise definition.

Substances of doubtful formula would have their names in the official dictionary prefixed by "d" (Latin: *dubium*). Substances of unknown composition could be given a name indicating their class, if known, or if not, a name with a special ending for unknown substances.

The above is intended only as a rough outline of what lines a really systematic system of nomenclature might take. The subject is an important one, and it is to be hoped it will receive the attention it deserves. Should circumstances warrant it, the author hopes to publish later an application of the scheme to more complicated compounds. In the meantime, he would welcome suggestions and criticisms.

Chemical Department,
Royal Technical College, Glasgow.

THE DEVITRIFICATION OF GLASS, A SURFACE PHENOMENON. THE REPAIR OF CRYSTALLISED GLASS APPARATUS.

By ALBERT F. O. GERMANN.

It has generally been supposed that the devitrification of blown glassware in storage or in daily use is a phenomena similar to that studied by Tammann (Tammann, *Z. Elektrochem.*, 1904, x., 532), Guertler (Guertler, *Z. anorg. Chem.*, 1904, xl., 268), and others, which depends on the tendency of a supercooled liquid to form crystal nuclei, from which crystallisation proceeds. Tammann showed that spontaneous devitrification depends on two factors, which seem to be related to the viscosity of the supercooled liquid: the tendency to form crystal nuclei, which increases with the degree of supercooling, though the rate at which nuclei have been observed to form reaches a maximum, and then on account of the damping effect of the diminishing temperature on the speed of formation, rapidly decreases, and for most glasses reaches a value of zero at room temperature; and the speed with which crystallisation proceeds from the crystal nucleus, which for commercial glassware also reaches a value of zero for ordinary temperatures. Tammann has shown that certain substances in solution act catalytically on the formation of crystal nuclei, and that in certain instances the rate may be depressed to zero even in the temperature range of the maximum. This is evidently the ideal condition for chemical glassware, a conditon more or less successfully achieved by glass manufacturers.

It has also been shown (Herbert Jackson, Chemical News, 1920, cxx., 62) that by repeated fusion and solidification supercooled liquids which otherwise devitrify readily can be obtained in the vitreous state. In all cases of this sort that have been studied, water vapour is given off progressively during the process of fusion, and with the removal of it the vitreous state has been found to persist more and more. Subsequent re-introduction of water has been found to promote crystallisation. Herbert Jackson is responsible for the statement that the conclusion seems to be justified that water, and to a smaller extent, carbon dioxide act chemically when many glasses are heated in flames, and that this action plays an important part in the initial stages at least of devitrification. This is undoubtedly true, for it is known that certan glasses, which devitrify very readily in the gas flame, can be worked if heated by radiation. A glass containing barium oxide, which was very stable when heated by radiation in a muffle furnace, quickly devitrified in a gas flame, first becoming grey; under the microscope the grey appearance was shown to be due to the separation of minute bubbles, apparently caused by rapid absorption and subsequent evolution of gases (H. Jackson, *loc. cit.*).

Splitgerber (Splitgerber, *Pogg. Ann.*, 1851, lxxxii., 453) relates his experience with a bit of glass at least 10 years old (most chemists will recall similar experiences): the lenses from a pair of glasses had to be reset, and during the process were heated over a spirit lamp; the surface became roughened and as if frosted over. He showed that this was caused by the driving out of moisture from the glass surface, moisture which was chemically combined. This behaviour is not given by a fresh surface, for a piece whose surface had clouded on heating was ground down and polished, and when again heated showed no clouding.

It has often been noted that glass, under certain conditions, shows efflorescences of sodium hydrogen carbonate on its surface; I have preserved a number of unused test-tubes, imported from Germany before 1914, each of which shows such efflorescences. These tubes all show a marked tendency to devitrify when heated.

It is possible to explain devitrification of chemical glassware as a purely surface phenomenon, unrelated as to immediate causes to the phenomena observed by Tammann.

Much has been said about the surface film of moisture on glass which has come to equilibrium with the atmosphere, but the tremendous affinity of glass for moisture is nevertheless too little appreciated; let me recall an observation made by Moissan that ought to be better known.

"The affinity of dry glass for moisture is so great that carbon dioxide saturated with water vapour at —20° must be passed (through a tube of dry glass containing sodium hydride) for several hours before the gas reaches the hydride in a moist condition" (*Compt. Rend.*, 1903, cxxxvi., 723).

The silicates of which the glass is composed are in equilibrium with this water, and must be more or less hydrolysed, depending on the composition of the glass, so that we may assume the presence of silicic acid, calcium hydroxide, and sodium hydroxide; the bases, however, absorb carbon dioxide from the air, and so are converted to the hydrogen carbonates. The efflorescence is thus directly explained. Washing removes most of

these carbonates. Heating, however, drives off adsorbed moisture, dehydrates the silicic acid, and roughens the surface, depending on the extent of the "weathering" of the glass. The separated silica forms an infusible coating over the surface of the glass, which may under certain conditions dissolve in the underlying silicate, and the surface clear up, or under other conditions yield difficultly fusible calcium silicate, in which case well-defined crystal surfaces may appear (I have preserved a tube of heavy glass which, when heated, developed into what appears to be an excellent example of this sort), the subsequent phenomena being closely similar to the devitrification studied by Tammann and by Guertler, except that crystallisation proceeds from the surface, and not from crystal nuclei on the interior of the mass.

To test the possible correctness of this view, the surface of a tube that had become badly devitrified before the blowpipe was carefully washed with dilute hydrofluoric acid, to remove the separated silica from the surface, and an attempt was again made to work the glass in the flame. The result was remarkable, but entirely in keeping with the hypothesis; as the glass reached the softening point, it became perfectly clear, and could be blown as well as the best new glass. The same result was attained by removal of the surface layers by washing with dilute hydrofluoric acid before heating the glass in the flame, so avoiding any tendency towards devitrification.

At the same time, the older hypothesis, that sodium oxide is slowly volatilised by long continued heating of glass near its softening point must not be lost sight of, for glass which shows no initial tendency to devitrify does so if kept in the flame too long. A common practise has been to reintroduce the lost alkali by some method, but this is always difficult to do. Treatment with hydrofluoric acid, however, is very simple, and thoroughly effective.

At the Morley Laboratory, we have had some difficulty during the past few years in obtaining suitable glass for constructing apparatus for work with gases. Much of Pro. Morley's apparatus remains, but practically all of it devitrifies when the effort is made to work it in the flame. With the new method, however, all of it at once became available for use. Five advanced students, working on various phases of the physical chemistry of pure and mixed gases, each of whom has had to construct his own apparatus, have been able to work without fear of loss through devitrification, which has always been a source of much annoyance to beginners in the art of glass-blowing.

If the devitrification of glass were dependent upon the formation of crystal nuclei upon the surface or within the mass of the glass, a cool storage space would seem to be ideal; my experience has, however, been that glass which had been stored in an attic room under a slate roof for 15 years showed less tendency to devitrify than another lot stored in a ground-floor room of our reinforced concrete laboratory for five years. This is perplexing unless we admit that devitrification depends upon absorption of moisture; the atmosphere of the laboratory has an average humidity much higher than the atmosphere of the attic room, which is in another building. Certain gases present in the atmosphere of a chemical laboratory also seem to play a part, probably acting catalytically; halogen gases, except those containing fluorine, for obvious reasons, seem especially active in this way. A tube which had contained phosgene devitrified badly before the blowpipe; the same tube, after having been exposed casually to the laboratory fumes for more than six months, no longer showed any tendency to devitrify.

Summary.

That the devitrification of glass before the flame is a surface phenomenon is shown by the fact that the tendency to devitrify may be removed by rinsing the parts to be fused with dilute hydrofluoric acid, thus removing the surface. Old apparatus which has been broken may be repaired by taking advantage of this fact.

THE BRITISH GAS MANTLE INDUSTRY.

Among the industries that are seeking State assistance through the projected Government Bill relating to "key" industries are the gas-mantle and subsidiary industries. On behalf of these a statement has been presented to the Board of Trade by the Incandescent Mantle Manufacturers' Association, the main points of which are summarised below :—

The Gas Mantle Industry bases its claim to be regarded as a "key" industry upon the following considerations :—(1) Both in time of peace and in time of war incandescent gas lighting is necessary for the adequate illumination of docks, railways, factories, &c. (2) It is estimated that 32 million tons more coal would be required yearly to produce the same illumination if flat-flame burners were used instead of gas mantles. (3) The "stripping" of coal gas has been found necessary to ensure adequate supplies of benzol, toluol, and other hydrocarbons for the manufacture of dyes, drugs, and explosives; such "stripped" gas can only be used as an illuminant in conjunction with the gas mantle. The value of the industry from the standpoints of efficient illumination and coal conservation was recognised by Lord Balfour of Burleigh's Committee on Commercial and Industrial Policy, and recent legislation authorising the sale of gas on a calorific, instead of an illuminating basis has further emphasised the importance of the gas mantle. In Germany the essential nature of this industry, including the raw materials therefor, has been recognised by granting special allocations of coal at the lowest price and supplies of gas which are otherwise restricted.

Before the war, the rare-earth chemicals and the gas-mantle industry were mainly under foreign domination. The total output of Indian monazite sand went to Germany, and British mantle-makers had to purchase thorium nitrate abroad at a price fixed by the Thorium Convention, a combine of German and Austrian manufacturers which was itself controlled by the chief German maker of gas mantles. Further, foreign mantles were sold in this country at prices 2—35 per cent below English factory costs, and 23—70 per cent below the selling prices in the countries of origin. In 1913 foreign importations amounted to between 45 and 50 million finished mantles and over 11 million partly finished (about 70 per cent of our entire

consumption), and the latter were marketed in such a way as to evade the payment of British income tax by the English branch of the German combine, the Auer Gesellschaft. In the same year the English production was 22 million mantles, of which 10 million was made by a company associated with the German combine.

In consequence of this foreign domination the home industry became very precarious; nearly all the factories were running at a loss, wages were low, and employment uncertain and unsatisfactory. Hence, at the outbreak of war, there was insufficient plant to meet the country's requirements, supplies of thorium nitrate were cut off, and there was a shortage of clay rings and other materials required by the industry. To overcome these difficulties the Indian monazite deposits were placed under British control, and five home manufacturers took up the preparation of thorium nitrate, although until the factories were ready the nitrate had to be purchased abroad at arbitrary prices which showed large profits to foreign suppliers. These factories can now produce all the gas mantles the country requires; and during the war they supplied the cerium fluoride and cerium oxalate needed for searchlights and tracer bullets. Prior to the war all the mantle rings required by the home industry were either imported from Germany or supplied by a German-owned company with branch works in this country. These works were purchased by a group of the chief British mantle-makers and so extended that they are now able to meet the country's requirements, although not yet in a position to produce the full range of designs which were offered by the Germans. Ramie yarn, which was also derived from Germany before the war, can now be supplied by British spinning plants in sufficient quantity to meet all requirements.

Owing to the extensions made to buildings and plant (at war prices), and to the establishment of three of four new factories, the output capacity of the home industry is now over 130 million mantles per annum, which is sufficient to leave a considerable surplus for exportation. The following data show the position of the British industry in 1913 and on October 30, 1920 :—

	1913.	1919-20.
Output of mantles ...	32,000,000	82,322,000
Capital employed	£440,670	£1,525,710*
Workers employed ...	1,843	3,783

* Exclusive of £350,000 invested in the thorium nitrate and other subsidiary industries.

The present annual consumption of gas mantles is valued at £1,750,000; £400,000 is paid in direct wages, and at least an equal sum as indirect wages to convert the imported raw materials into the products used by the industry, labour, and wages entering into the cost of the finished article to a degree unusual in other industries. The raw materials used by the gas-mantle manufacturer include thorium nitrate and other chemicals, cotton, ramie, artificial silk, asbestos yarns, clay rings, and cardboard boxes. At the present time there is grave stagnation in the above trades, which is mainly due to the increasing importation of foreign mantles (over 10 million in 1920), and the prospect of further competition at prices below British manufacturing costs. The low prices of foreign mantles are the result of :—(a) Attempts by foreign makers to recapture their former markets at any cost; (b) the low rate of foreign exchanges; (c) longer working hours in foreign factories (60 hours or more per week compared with 48 in this country) and the lower standard of living of the worker; (d) large pre-war stocks of certain raw materials held by German manufacturers. The British consumer is not obtaining the full benefit of the lower prices, as the intermediate profit is mainly retained by the importers and dealers. The Labour representatives on the Joint Industrial Council for the industry proposed a resolution, which was passed unanimously, deploring the increasing importation of foreign mantles, and urging the Government to take steps to counteract the effects due to foreign rates of exchange. At the present time some of the British factories are closed down, and the rest are working short time; manufacturers are carrying large stocks at a season when demand normally exceeds the rate of production; employment in the industry is declining, and generally the situation is so serious that immediate action is imperatve. In concluson, it is submitted that the manufacture of thorium and rare-earth salts, incandescent mantles, and clay rings, be recognised and assisted as "key" industries; that legislation be introduced forthwith to protect the British worker against unemployment resulting from foreign competition; and that the British manufacturers who have responded to appeals to lay the foundations of a self-supporting industry be assured a market free from unfair competition.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, February 24, 1921.

PROF. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read :—

"A Remarkable Flint Implement from Selsey Bill." By SIR E. RAY LANCASTER, K.C.B., F.R.S.

The implement described, and depicted in four careful wash-drawings of the natural size, together with two hammer-stones obtained with it, was found resting with other large broken flints on a bed of clay underlying "the Coombe rock gravel," and exposed by tidal action on the shore of Selsey Bill, by Mr. Edward Heron Allen, F.R.S., in 1911. It is remarkable for its large size, being eight inches long and weighing 5lb. 9oz. It is of rostrate form, with a convex dorsal and flat ventral surface, and has been shaped by powerful blows, resulting in coarse flaking of undoubted human workmanship. It belongs to a very early palæolithic horizon, probably "pre-Chellean." The only flint implements of similar weight and size known are two also of very early (viz., Upper Pliocene) age. One is from the Suffolk bone-bed, 8¾lb. in weight, and is figured in the *Phil. Trans.*, B, ccii., 323, 324; and one weighing 7lb. 6oz. was discovered last September by Mr. Reid Moir with a large number of remarkable "worked" flints on an ancient workshop floor beneath the forest-bed at Cromer. The question is raised as to how such unwieldy implements could be handled and for what purpose. It is suggested

that the race of men who made and used them had larger hands and more powerful limbs than have more modern races.

"*Regeneration and Reproduction of the Syllid Procerasta.*" By E. J. ALLEN, D.Sc., F.R.S.

Procerastea Halleziana was found living in membranous tubes on the stems of the hydroid Syncoryne. The worm was observed to feed by piercing the body-wall of the hydranths with its extruded pharynx and pumping out the contents of the gastral cavity of the hydroid. The proventriculus of the worm functions as a quick-acting pump, making from 150 to 200 pulsations a minute.

Sexual reproduction in Procerastea is quite similar to that in Autolytus, each individual forming a single large stolon (with stolon-head on segment 14), which is set free as a male Polybostrichus or a female Sacconereis, before a second stolon is produced.

In addition to sexual reproduction, the procerastea were found to be undergoing rapid multiplication by a process of asexual reproduction, consisting of fragmentation, followed by the regeneration of anterior and posterior ends.

Fragmentation can be induced by artificial means, and takes place in a definite way. The head and first seven setigerous segments form the first piece. This is followed by three sections, of two segments each; these by three sections, of three segments each; and these by four or five sections, of four segments each. Behind these, sections of three segments reappear and are continued to the pygidium.

Experiments showed that the rate of regeneration of the different sections varied according to the region of the body from which they came, being most rapid in those from the middle region.

Regeneration of anterior segments appears to continue until the original segments come to occupy exactly the same position in the regenerated worm as they had occupied in the parent, and then stops. Posterior regeneration was more active when the original segments came from the anterior end of the parent worm. The posterior portion of a female stolon regenerated a complete *souche* of 13 segments, and had commenced to regenerate a stolon-head when it was found.

"*The Enzymes of B. coli communis.* Part II.—(*a*) *Anaerobic Growth followed by Anaerobic and Aerobic Fermentation.* (*b*) *The Effects of Aeration during the Fermentation.*" By E. C. GREY and E. G. YOUNG.

Section A.—Anaerobic fermentation of glucose by an emulsion of *B. coli communis* proceeds differently according as the organisms have been grown previously with or without oxygen.

When the immediate past history has been anaerobic, the fermentation under anaerobic conditions yields very little or no lactic acid and greatly diminishes succinic acid. In place of these, acetic acid appears in large proportion. Admission of oxygen during the fermentation leads to lactic acid production. The fact that acetic acid replaces succinic acid entirely gives additional proof of the close relationship of these two substances.

The results also confirm the conclusions of the earlier sections as to the independence of the lactic acid, acetic acid and probably of the carbon dioxid fermentations.

Section B.—The effect of introducing oxygen in the fermentation of glucose by *B. coli communis* is to increase the lactic, acetic, and succinic acids, and to diminish the hydrogen, carbon dioxide, and formic acid, but to leave the alcohol unchanged.

Under anaerobic conditons greater variations occur in the proportion of alcohol to acetic acid than under aerobic conditions, and it would appear that one of the effects of the introduction of oxygen during the fermentation is to inhibit the mechanism of auto-reduction, which is responsible for the variations in alcohol when such occur.

Contrary to expectaton, the products of aerobic fermentation contain not more, but less, oxygen than the corresponding products of anaerobic fermentation of glucose; but there is a gain of oxygen in both cases upon the original glucose. If, as seems likely, this extra oxygen comes from the water, then it would appear that one of the effects of the introduction of oxygen is to diminish the part played by water in the reactions.

"*Anthocyanins and Anthocyanidins.*"—Part IV. By A. E. EVEREST, D.Sc., and A. J. HALL, B.Sc.

The paper deals with the constitution of the blue anthocyan pigments in flowers and with the manner in which anthocyan pigments are formed in Nature.

The conclusions of Shibata, and Kasiwagi, concerning the constitution of the blue anthocyan pigments in flowers are compared with those of Willstätter and Everest. Evidence is produced which indicates important differences between the complex salts known to be formed by the anthocyan pigments (and other pyrylium compounds) with the salts of such metals as iron and the blue pigments present in flowers. Reasons are given for concluding that such of the blue plant pigments of this group as have been investigated do not belong to the former series, but are probably comparable to the alkali phenolates of the flavonols.

Evidence is produced which considerably strengthens the conclusion, already expressed by Keeble, Wheldale, Everest, and others, that in plant synthesis the flavonols are first formed, and from them the anthocyans—not *vice versâ.*

PHYSICAL SOCIETY.

February 25, 1921.

PROF. SIR W. H. BRAGG, F.R.S., President, in the Chair.

THE following papers were read :—

"*A Note on the Hot Wire Inclinometer.*" By R. H. HUMPHREY.

Two fine platinum wires were stretched parallel to each other in a hole in a copper block, and were heated electrically in a Wheatstone bridge arrangement. The changes caused by rotation were investigated with hydrogen, air, and carbon dioxide surrounding the wires. It was found that both for the same current, and for the same temperature of the wires, the inclinometer filled with carbon dioxide was much more sensitive than one

filled with air. The shape of the curves obtained suggests that the temperature gradient in the region traversed by the wires is nearly uniform, the difference of temperature of the layers of gas in which the wires happen to be being sensibly proportional to the vertical distance between them.

DISCUSSION.

Dr. J. S. G. THOMAS said that the conditions under which the author's experiments were carried out made the results quite incomparable with those described in his own paper on the subject. In his experiments the free convection was of much greater importance than the conduction loss, whereas in the present paper the arrangement of the apparatus was such that conduction preponderated. For example, the wires were much too near the walls of the containing chamber. The statement that for the same current the effects in carbon dioxide are greater than in air is exactly what would be expected if conduction predominated, but was opposite to what happened in his experiments in which convection predominated. In the latter case, the specific gravity and specific heat entered into the problem. He had made a calculation of the heat loss by conduction in hydrogen, air, and carbon dioxide, using King's formula, and found these to be in the proportion of 12 : 100 : 200. From Fig. 3 we find that the heat losses in the author's experiments are very closely in this ratio, which bears out the conclusion that conductivity was the predominant factor. The temperature of the wires in the experiments of Fig. 3 should be stated. Another difference between the author's experiments and his was that the wires were too far apart to bring the joint effect due to shielding of the second wire by the first into play.

Mr. J. GUILD said it was of interest to him that so many workers seemed to have taken up the somewhat obvious suggestion he had made, in discussing Mr. Thomas's paper, of investigating the temperature distribution in the neighbourhood of a hot body by means of the interferometer. He would like to give a word of caution in connection with the method, which was that the contour fringes observed would only be true isothermals if the wire were infinitely long in the direction of vision. In ordinary conditions a slight correction for end effects would have to be made in obtaining quantitative data from the fringe system.

Mr. F. E. SMITH asked if experiments had been made at different pressures.

Mr. HUMPHREY, in reply, said he was fully sensible of the truth of Dr. Thomas's remarks about convection and conduction. With regard to the experiments of Fig. 3, the temperature of the wire was 130° C. to 140° C. in each case. He had not noticed that the figure gave ratios so close to those given by King's formula. As regards the mutual influence of the wires, the region to which the effect of the upper wire extended could be very easily seen from the interferometer experiments. In reply to Mr. Smith, he had not experimented at different pressures.

"The Magnetic Susceptibility of Certain Natural and Artificial Oxides." By PROF. E. F. HERROUN and PROF. E. WILSON.

(1) The susceptibility of ferric oxide, as occurring in nature, varies through a wide range, but in the case of artificial preparations the range of variation may be much greater.

(2) The highest susceptibility exhibited by artificial ferric oxide occurs when either ferrous or magnetic oxide is oxidised at a high temperature in the anhydrous condition. From hydrated magnetic oxide the susceptibility, though considerable, is much less.

(3) The lowest susceptibility is obtained from native hæmatites, or naturally oxidised chalybite, or by the ignition or precipitation of ferric salts.

(4) It appears that the passage through the stage of magnetc oxide impresses more pronounced magnetic properties upon the resutling ferric oxide.

(5) The actual values of susceptibilty have been obtained in the case of ferrites, one of the most conspicuous being that of copper.

(6) Heating feebly magnetic ferric oxide with a basic oxide, *e.g.*, lime or magnesia, increases susceptibility (confirming List and others).

(7) When higher susceptibility has been produced by heating ferric oxide with a basic oxide such as that of silver or mercury, subsequent removal of the metal leaves the ferric oxide in a magnetic condition.

(8) The chemical compounds (aluminates) formed when ferric oxide is replaced by alumine oxide show no definite increase in susceptibility, which is in marked contrast with the ferrites.

DISCUSSION.

PROF. BRAGG showed a model of the molecule of magnetite as deduced from its X-ray spectra, and pointed out various conclusions which could be drawn from it. For instance, it was impossible to deduce the properties of the magnetite from those of Fe_2O_2, and FeO, nor could any of its properties be ascribed to one or the other, because the crystalline form of the Fe_2O_3 and FeO in the magnetite molecule differed from their crystalline form when separate. It was possible by X-ray spectroscopy to say what crystals were present in any powder. No doubt magnetic effects were associated with the crystal structure; but experiments on Pyrrotine showed no difference between the magnetised and unmagnetised state.

DR. RAYNER asked if differences in aggregate form rather than in crystal form might not account for the different magnetic properties of some substances of the same composition.

PROF. WILSON said he was disappointed by Prof. Bragg's remark about Pyrrotine, as it partially answered the question he wished to ask. Would the X-ray spectroscope be likely to show any difference in the two ferric oxides of such widely different susceptibilities mentioned in the paper?

PROF. BRAGG: If there is any difference in crystal structure it would show it.

MR. GUILD said the case of Pyrrotine was different from that of the two ferric oxides. The experiment with Pyrrotine showed that there was no difference in the molecular structure of a magnetisable substance when magnetised and unmagnetised. This one would expect since the phenomena of magnetisation are accounted for by the orientation of the molecules, and not by any alteration of their properties. The case of the two ferric oxides in which Prof. Wilson was interested was quite different. Here we had magnetisable and non-magnetisable modifications of

the substance. In this case one would expect to find a difference in molecular structure revealed by the X-ray spectrometer.

DR. J. S. G. THOMAS asked if the differences might not be due to differences in the magnetic coupling of the electrons.

PROF. BRAGG: That is the problem we are all working at. In the case of the diamond there is no doubt that the carbon atoms point in opposite directions.

PROF. HERROUN said that in Pyrrotine the susceptibility in one direction was 70 times that in another. Would the X-ray spectra give any clue to this?

"The Refractometry of Prisms." By J. GUILD.

In this paper a generalised formula for the refraction of light through a prism is obtained, and the particular cases pertaining to practical methods of refractometry deduced from it. The sensitivity of various methods for various prism angles and refractive indices is shown in a series of curves as is also the liabilty to error due to errors in auxiliary constants.

DISCUSSION.

MR. T. SMITH agreed that information such as that in the paper would help to dispel the illusions concerning the accuracy of their observations which most workers on refractive index measurement seemed to possess. He had had occasion to analyse results supposed to be the last word in accuracy, but had found quite serious errors in many of them.

He would like to see the general adoption of some system of angular notation such as that used in the paper. The only case which presented difficulty was when applying it to a system in which there were reflecting as well as refracting surfaces. He had found it convenient in such cases to keep to the angle convention, but to change the signs of the refractive indices after reflection.

DR. D. OWEN said the author had been speaking of tolerances of a few seconds. As a rule one felt satisfied when one got angles correct to a minute. What was the accuracy in angle which the author considered should be attained in precise measurements?

MR. GUILD said that accuracy in angle measurements was largely a matter of choosing proper methods and apparatus. For the cases most frequently met there was no great difficulty in measuring to a second provided the surfaces of the prism were such that this accuracy had any meaning. He was at present experimenting with a very cheap and simple arrangement with which he hoped to reach a tenth of a second in cases which were fit for such precision.

"Tracing Rays through an Optical System." By T. SMITH.

The paper, which is mainly mathematical, is a further development of the system described by the author in the previous papers of the same title presented to the Society; formulæ for skew rays are put into shape as far as possible similar to those applying to rays in one plane.

INSTITUTE OF CHEMISTRY.

Forty-third Annual General Meeting.

SIR HERBERT JACKSON, the retiring President, in the course of his Address, remarked that Government Departments and official authorities generally had shown more inclination in recent times than in the past to accord higher recognition to the services of men of science. The conditions of appointments of chemists, both in the Government service and in industry had been improved, and until the close of 1920 the profession had been in almost a unique position in that very few indeed of its members were disengaged. The prevailing depression in industry had had some effect on the employment of chemists, but even now less than 50 were disengaged out of nearly 3,300 on the Roll. The By-laws of the Institute had undergone revision to provide for the representation of chemists from various parts of the country and practising in different departments of work, and alterations had been made to define more specifically certain points relating to the ethics of the profession and further to restrict the membership of the Institute to British subjects. The Institute was taking part in many matters affecting the public life of the country where chemistry was concerned, and the Annual Report showed that chartered professional bodies of this character were able to render the State valuable service. The greater consideration given to science by the Government was an encouragement to the coming generation of chemists to follow a career of essential and vital importance to the needs of the country. It would probably be regarded as desirable at the present moment for the Council of the Institute, without taking part in politics, to give expression to their views on the grave importance of maintaining in this country industries on which not only the future development of our chemical industry and many allied industries depends, but the future of a very large number of students of chemistry who are now in the course of training. The Institute was entrusted by its Charter with securing the supply of well-trained chemists, but unless a great chemical industry was maintained there would be a very poor prospect for them. The President maintained that the Institute had throughout its existence fulfilled the purposes for which it was incorporated. It had kept alive the corporate spirit of the profession, the means whereby the opinions and views of its members found expression in matters of public concern. It was the officially-recognised public body to whom the country could turn for advice and guidance on matters relating to the profession. It rendered every possible assistance to those who intended to follow the profession of chemistry, and promoted and maintained the highest standard of training and competence for that profession. It registered the trained and competent and thereby supplied competent professional service for the country. Moreover, it promoted the strictest integrity on the part of its members in their dealings with one another and with the public, and fostered by every means in its power the status of the profession. He was confident that it would continue to gain strength and prestige.

Mr. Alfred Chaston Chapman, F.R.S., succeeds Sir Herbert Jackson as President. The Officers

and Council were elected as nominated and the Censors and Auditors were elected for the ensuing year. *President*—Alfred Chaston Chapman, F.R.S. *Vice-Presidents*—Horatio Ballantyne, Ernest Mostyn Hawkins, Sir Herbert Jackson, K.B.E., F.R.S., William Macnab, C.B.E., Gilbert Thomas Morgan, O.B.E., D.S.c, F.R.S., George Stubbs, C.B E. *Hon Treasurer*—Edward William Voelcker, A.R.S M. *Members of Council*—Walter Ernest Adeney, D.Sc., A.R.C.I. (Dublin), Wm. Bacon, B Sc. (London), Francis Howard Carr, C.B.E. (London), Arthur Jenner Chapman (London), Allin Cottrell, M.Sc. (Oldham), Alexander Charles Cumming, O.B.E., D.Sc. (Edinburgh), Frederick George Donnan, C.B E., F.R.S. (London), Lewis Eynon, B.Sc. (London), Alexander Findlay, M.A., D.Sc., Ph.D. (Aberdeen), George Watson Gray (Liverpool), Frank William Harbord, C.B.E., A.R.S.M. (London), Charles Alex. Hill, B.Sc. (London), Patrick Henry Kirkaldy (London), Frederic Herbert Lees (London), Samuel Ernest Melling (Manchester), Gordon Wickham Monier-Williams, O.B.E., M.C., M.A., Ph.D. (London), Harold Moore, O.B.E., B.Sc. (London), Andrew More, A.R.C.S. (London), Frederic Mollwo Perkin, C.B.E., Ph.D (London), Benjamin Dawson Porritt, M.Sc. (London), Thomas Slater Price, O.B.E., D.Sc., Ph D. (London), William Rintoul, O.B.E. (Ayrshire), William Henry Roberts, M.Sc. (Liverpool), John Rogers, O.B.E. (Glasgow), Ernest Woodhouse Smith, D.Sc. (London), Leonard Ellerton Vlies (Manchester), Sir James Walker, C.B.E., F.R S. (Edinburgh).

SOCIETY OF PUBLIC ANALYSTS.

March 2, 1921.

Mr. Alfred Smetham, President, in the Chair.

A Certificate was read for the first time in favour of Mr. Percy N. Mould.

Certificates were read for the second time in favour of Messrs. Jules Cofman-Nicoresti, Walter K. Fletcher, William Singleton, Francis G. H Tate, James Darnell Granger, Ph.D., F.I.C., Ed. B. Maxted, Ph.D. (Berlin), B Sc., Russell G. Pelly, F.I.C.

The following was elected a member of the Society: Mr. W. R. Schoeller, Ph.D.

The following papers were read:—

"The Acidity of Ink and the Action of Bottle Glass on Ink." By C. Ainsworth Mitchell, M.A., F.I.C.

The author gave the reason for the addition of acid to ink and the amount present in standard inks. He described acid-free inks, the estimation of acidity and the difficulty caused by dye-stuff. The hydrogen peroxide method was dealt with, its limitations and uses, and the estimation of total acidity as a check on the manufacturing process. Lastly, the author described the various effects of glass on ink. A number of exhibits were shown.

"The Detection of Adulteration in Butter by Means of the Melting-Point of the Insoluble Volatile Acids." By George Van B. Gilmour,

The author described how small amounts of coconut and palm-kernel fats added to butter lower appreciably the melting-point of the insoluble volatile acids. Tables of melting-points and distillation figures for pure fats and mixtures were given, also graphs showing how the melting point is affected when increasing quantities of coconut and of palm-kernel fat are added.

"Method and Apparatus for Routine Determination of Melting-Points of Fats and Fatty Acids." By S. H. Blichfeldt and T. Thornley.

The authors describe how a column of melted fat 1 cm. long in a tube of 1 mm. bore, 3 mm. diameter, and 60 mm. long, is rapidly solidified on ice, and kept on ice during two hours; it is then placed in a water-bath with the upper level of column 1 cm. below the surface, and heated at 1° C. per minute. The temperature at which the column rises is noted as M.P. The apparatus is a rectangular glass water-bath holding 20 tubes, and arranged for electrical heating, stirring, and lighting.

NOTES.

Royal Institution.—A General Meeting of the Members of the Royal Institution was held on the 7th inst., Sir James Crichton-Browne, Treasurer and Vice-President, in the Chair. Sir Frank Benson, Mr. I. W. Bullen, Mrs. R. C. Bussell, Miss. E. Caird, Mr. C. H. Combe, Mr. H. R. Darlington, Mr P. Faraday, Mr. G. J. Goldie, Major Gordon Home, Mr. W. G. Klein, Dr. A G. Levy, Miss J. Lindley, Mr. E. MacRury, Mr. M. R. Trower, Mrs. Ractivand, Sir Robert Robertson, and Miss L. C. Western were elected Members. The Secretary reported the deaths of Professors Odling and L. C. Miall, and resolutions of condolence with the relatives were passed.

Royal Institution.—The following the the Lecture arrangements at the Royal Institution after Easter: Professor R. A. Sampson on (1) "The Nebular Hypothesis," (2) "Measurement of Starlight"; Dr. Keith, four lectures on "Darwin's Theory of Man's Origin"; Mr. Clodd on "Occultism"; Sir James Frazer on (1) "Roman Life (Time of Pliny the Younger)", (2) "London Life (Time of Addison)"; Dr. C. T. R. Wilson on "Thunderstorms" (the Tyndall Lectures; Mr. H. S. Foxwell on "Nationalisation and Bureaucracy"; Dr. C. S. Myers on "Psychological Studies—(1) Localisation of Sound, (2) Appreciation of Music"; Mr. D. S MacColl on "War Graves and Monuments"; Sir Alexander Mackenzie on "Beethoven"; Dr. H. H. Dale on "Poisons and Antidotes"; Mr. H. Y. Oldham on "The Great Epoch of Exploration—(1) Portugal, (2) Spain"; Mr. C. C. Baly on "Chemical Reaction"; Mr. F. Legge on "Gnosticism and the Science of Religions"; and Dr. R. S. Rait on (1) "Scotland and France", (2) "Scott and Shakespeare". The Friday evening meetings will resumed on April 8, when Dr. R. H. A. Plimmer will deliver a discourse on "Quality of Protein in Nutrition." Succeeding discourses will probably be given by Mr. Ernest Law, Sir James Walker, Sir Frank Dyson, Astronomer Royal, Sir Robert Robertson, Dr. Bateson, Dr. Starling, Mr. A. Mallock, Dr. Leonard Huxley, Dr. A. G. Webster,

TETRALINE IN MANUFACTURE OF LAKES AND VARNISHES.—The varnish substitutes employed during the war in Germany were far from satisfactory. However, those with base of teraline, alone or mixed with other usual solvents, were so. The dissolving action of various tetralines were varimade. For example, varnishes are made by preparing a saturated solution of lake in tetraline and diluting it with a miscible solvent with a slight lake-dissolving power and more rapidly volatilised than tetraline. Such a varnish allows of a second coat without softening of the first. Tetralines have a slight odour of camphor which can easily be masked by adding a little spirit of turpentine.—*Industrie Chimique*, January, 1921.

TECHNICAL COLLEGE, BRADFORD.—A course in Public Health, designed to meet the needs of qualified medical practitioners who may wish to obtain the Diploma in Public Health of the Royal College of Physicians of London, and Surgeons of England, has been arranged by the Technical College Committee and the Health Committee of the City Council. For this purpose the Technical College has recently been placed upon the list of recognised Institutions by the Royal Colleges. The proposed course will extend over 25 weeks, and will include lectures and laboratory work in bacteriology and pathology, and in chemistry. The course in bacteriology will be conducted in the Public Health Laboratories. In connection with this work, Dr. William Campbell has been appointed Lecturer in Bacteriology and the Pathology of Industrial Diseases, and Dr. R. Cecil Robertson has been appointed Assistant Lecturer and Demonstrator in Serology and Immunology in the College. Both gentlemen are members of the permanent staff of the Bacteriological Laboratories. The course in Chemistry, which will be under the direction of the Head of the Chemistry Department of the Technical College, Dr. R. D. Abell, will be conducted in the Chemical Laboratories of the College. The recognition of the College for post-graduate work of this nature marks an important point in the development of the work of the College. The extension of the post-graduate section of the work of the College is receiving ample attention, and increasing provision for this work in the College is now being made

ACTION OF CHLOROPICRINE ON THE GERMINATIVE FACULTY OF SEED.—Experiments made by M. E. Miège demonstrate that parasitic insects on seed can be destroyed by chloropicrine in 24 hours, utilised in the proportion of 15 to 20 cubic cm. per cubic metre of seed. Longer contact and larger quantities seem useless. The action of chloropicrine on seed varies with the species of seed, the percentage employed and the duration of treatment. Imperceptible on some (leguminous, linseed, &c.), it affects on the contrary the germinative faculty and energy of others (hemp, beet, and especially cereals). This unfavourable influence generally increases with quantity, and the length of time of treatment. In the conditions required for disinfection it may decrease the germinative power of wheat 30 per cent, and larger quantities are yet more noxious. On the contrary, the seed of leguminous plants is absolutely immune.—*Comptes Rendus*, January 17, 1921.

NEW PROCESS FOR MANUFACTURE OF SUPERPHOSPHATES.—A mixture of phosphorite, lime, and silica is heated to nearly the point of fusion. In these conditions a lime-silicite is formed which takes one or two molecules of lime from the tribasic phosphate of lime. The phosphate is thus brought to the mono or bicalcic state, and consequently soluble with organic acids.—*L'Engrais*, January 7, 1921.

FERTILIZING ACTION OF SULPHUR.—Experiments made by M. Nicolas demonstrated that besides the important qualities ascribed to sulphur, both as an aliment in form of sulphuric acid and catalytic agent in assimilation of nitrogen of the soil, there is also its nfluence n fixaton of atmospheric carbon owing to its action on chlorophyll. Thus its employment in agriculture deserves exhaustive researches.—*Comptes Rendus*, January 3, 1921.

REPORT OF IMPORTS AND EXPORTS BY AIR IN 1920.—The Air Ministry states that the value of imports and exports by air during 1920 exceeded a million pounds, the respective amounts being £677,047 and £339,108 and the grand total £1,016,155. For the last quarter of the year the value of imports and exports conveyed by aircraft were approximately four times greater than for the same period of 1919, although there was a reduction in traffic for the month of December as compared with the preceding months. The principal classes of merchandise carried during the year were clothes and furs. Among the imports, the largest item was one of about £307,500 for women's outer clothing brought from France. Fur goods valued at about £78,000 were also carried from France. In the export trade, the different classes of goods dealt with were more evenly represented. One of the chief items were men's and boys' woollen clothing, etc., to the value of £27,700.

THE SECRETARY of the Department of Scientific and Industrial Research makes the following announcement. The Lord President of the Council has established an Inter-Departmental Committee on Patents with the following terms of reference: (1) To consider the methods of dealing with inventions made by workers aided or maintained from public funds, whether such workers be engaged (*a*) as research workers, or (*b*) in some other technical capacity, so as to give a fair reward to the inventor and thus encourage further effort, to secure the utilisation in industry of suitable inventions and to protect the national interest; and (2) to outline a course of procedure in respect of inventions arising out of State-aided or supported work, which shall further these aims and be suitable for adoption by all Government Departments concerned. The Secretary to the Committee is Mr. A. Abbott, to whom all communications should be addressed, at 16 and 18, Old Queen Street, Westminster, London, S.W.1.

COTTON IN THE WEST INDIES.—Advices from the Imperial Department of Agriculture for the West Indies, dated December 14, state that the Pink Boll Worm of cotton, *gelechia gossypiella*, has unfortunately appeared in Montserrat and St. Kitts. Sir Francis Watts states that it has to be recognised that the appearance of Pink Boll Worm in the West Indies is a serious matter for the Sea Island Cotton Industry, and one of gravity for these islands, and particularly for those which, like Montserrat and St. Vincent, depend so largely upon the cultivation of cotton for their means of support. The whole question must engage the

serious attention of all concerned, including the Government and the cotton growers. It is improbable that the present cotton crop will be very materially reduced by the pest; and it is hoped that next year's crop will be safeguarded to a large extent by the steps that will be taken for the control of the pest.

BOOKS RECEIVED.

"First Course in General Science." By FREDERICK DELOS BARBER, A.M., MERTON LEONARD FULLER, A.M., JOHN LOSSEN PRICER, A.M., and HOWARD WILLIAM ADAMS, B.S. 607 Pages Illustrated. London: G. Bell & Sons, Ltd. Price 9s. net.

"Ammonia and the Nitrides, with Special Reference to their Synthesis." By EDWARD B. MAXTED, Ph.D., B.Sc., F.C.S. Illustrated, 112 Pages. London: J. & A. Churchill. Price 7s 6d. net.

"Lectures on the Principle of Symmetry and its Applications in all Natural Sciences." By F. M. JAEGER, Ph.D. Second augmented Edition, with 173 diagrams and three portraits. 347 Pages. Amsterdam: Publishing Company "Elsevier." 1920.

"Principles of Wool Combing." By HOWARD PRIESTMAN. Second Editon, enlarged and revised. 232 Pages. London: Bell & Son. Price 12s. net.

"The Chemistry of Enzyme Actions." By K GEORGE FALK, American Chemical Society Monograph Series. 136 Pages. New York: The Chemical Catalogue Company.

"The Physiology of Protein Metabolism." By E. P. CATHCART, M.D., D.Sc, F.R.S. 176 Pages. London: Longmans Green & Co. Price 12s. 6d net.

MEETINGS FOR THE WEEK

Monday, March 21.

Royal Society of Arts, 8. "X-Rays and their Industrial Applications" by Major G. W. C. Kaye.

Tuesday, March 22.

Mineralogical Society, 5.30.
Institute of Metals, 7.30. (At Birmingham).
Faraday Society, 8. "Some Aspects of the Scientific Work of the late Lord Rayliegh (Presidential Address)" by Prof. A. W. Porter. "The Forms of Electro-deposited Iron and the Effect of Acid upon its Structure" by W. E. Hughes. "The Electrolytic Recovery of Zinc" by S. Field. "Electrolytic Reduction of Glucose" by Prof. A. Findlay and V. H. Williams.

Wednesday, March 23.

Conjoint Board, 5.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

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LUMINESCENCE IN INORGANIC BODIES.
(A Critical Survey).

By J. FREDERICK CORRIGAN.

It is a commonplace in science that many of the old, long-familiar, and most frequently occurring of the natural phenomena which everywhere beset us, often fall into the category of things unexplained. By some ironical humour of the Gods, the quibbles and uncertainties of scientific knowledge often seem to centre around common occurrences, and to escape altogether the more complicated points. There exists a most wonderful and satisfactory way of accounting for the at one time mysterious deviations of gases from their "laws." The phenomena accompanying the electrolysis of solutions can be explained, and we can even account for the tricky habit which some organic compounds have of behaving as if they possessed two alternative formulæ. But where is the all-comprehensive theory which satisfactorily explains all the numerous facts connected with luminescence? It is not yet formulated. And luminescence is a phenomenon which must have set the human mind wondering ages before even an explanation of the nature of light was considered necessary. Luminescence has long been observed. It occurs both in the organic and in the inorganic kingdoms. Deep-sea creatures depend on it for their light; it is as the love-token in the insect world; and under some circumstances it is even the sign of death and decay.

However, it is beyond the scope of this paper to deal with the numerous forms of organic luminescence, our attention being given solely to the luminescence of the mineral world. Even here, the phenomena is very widespread and diverse, both in its mode of production and in its effects. Until recently, the literature on the subject was scant, contradictory, and unsatisfactory in the extreme. Even the very name of the phenomena has not yet been fully agreed upon, the terms "luminescence" and "phosphorescence" still being arbitrarily employed, although "fluorescence" is used to denote a modification of the phenomenon.

On consideration, it is evident that fluorescence is a form of phosphorescence, and for these two phenomena the term *luminescence* has been proposed by Wiedemann. Wiedemann suggests that all phenomena which involve the evolution of light not due to ignition should be classed under the general terms luminescence. Immediately we have two divisions:—

Luminescence { Fluorescence
Phosphorescence (Photo-luminescence).

When a body, such as a sulphide of an alkaline earth metal is stimulated by light, the later is absorbed, and at the same time, gradually evolved, even after the light stimulation has ceased.

A fluorescent solution, however, only gives off light as long as the light-stimulus is applied. If the source of light is cut off, the fluorescence immediately ceases. This, therefore, would appear to be the chief point of distinction between phosphorescence and fluorescence. Phosphorescence which is caused by light-stimulus may conveniently be named *photo-luminescence*, or the term *phosphorescence* itself may be retained for that particular phenomena.

Photo-luminescent or phosphorescent compounds were known long before they were "discovered" by the medieval alchemists. They were wondered at, and their preparation was very much sought after, but it was not until the close of the last century that a real enquiry into the nature and properties of these substances was begun.

Perfectly pure substances are considered to be incapable of phosphorescence, the phenomenon only being supposed to take place in a solid solution. If the supposition is correct, the amount of impurity required to produce phosphorescence must be exceedingly minute, for in the phosphorescent compounds prepared by H. Jackson (*Phil. Mag.*, 1898, xlvi., 402), the amount of impurity present was too small to be detected by ordinary means. Again, it is considered that a certain proportion of the impurity corresponds to a maximum effect of phosphorescence, the effect being diminished if the amount of the impurity is decreased or increased (Klatt and Lenard, *Wied. Ann.*, 1889, xxxviii., 90).

In confirmation of this, it is interesting to note that Mourelo (*Compt. Rend.*, cxxiv. (22), 1237) prepared pure strontium sulphide by reducing the sulphate with carbon, and also by treating the carbonate, heated to redness, with H_2S. The resulting purified product, he found, did not phosphoresce. If heated slightly, so that a little of the sulphide was oxidised to sulphate, the substance exhibited a brilliant phosphorescence. When, however, the substance was strongly heated, so as to convert a larger percentage of sulphide into sulphate, no phosphorescence was apparent, but on subsequent reduction with charcoal, the phosphorescence was again regained.

The nature of the impurity has apparently a great influence upon the colour of the phosphorescence. This may be strikingly demonstrated by placing in test tubes quantities of an alkaline-earth sulphide to which traces of metallic salts have been added. On exposing to the light of a magnesium ribbon, the tubes will be seen to glow in different colours, according to the nature of the impurity present. The following table, constructed mainly on the observation of Mourelo and Becquerel, depicts the variation in colour of the phosphorescent alkaline-earth sulphides, due to the presence of a second substance in minute amounts.

Impurity.	Colour of Phosphorescence
Mn	Yellow
Zn	Blue Green
Na	Yellow Green
Bi	Blue
Al	Red
Rb	Crimson
Li	Green

(Mourelo, *Compt. Rend.*, cxxvi. (21), 1508; cxxix. (26), 1336; Becquerel, *Compt. Rend.*, cvii., 892).

The temperature at which the phosphorescent substance is maintained has also an influence upon the colour of the resulting phosphorescence

Becquerel found that with a specimen of strontium sulphide, the colour of the phosphorescence could be altered from violet to orange simply by varying the temperature. Thus :—

Temp.	Colour of Phosphorescence
20° C.	Violet
40° C.	Blue
70° C.	Green
100° C.	Yellow
200° C.	Orange

Another factor which determines the character of the phosphorescence is the intensity of the light-stimulus. J. R. Mourelo (*Compt. Rend.*, 1899 cxxxviii., 557), showed that the phosphorescence of strontium sulphide is more intense and of a longer duration when the sulphide is light-stimulated by diffused light. Light stimulation by bright sunlight shortens the duration of the phosphorescence and lessens its intensity. The sulphides of calcium, barium, and zinc also share this property.

Diffused light also appears to increase the sensibilty of the substance to light-stimulation, and this sensibility may be further increased by repeated exposures to different light. Mourelo developed the sensibility of a specimen of strontium sulphide to such a degree that the light of a candle was sufficient to exert the necessary light-stimulus required for the phosphorescence. One specimen of strontium sulphide, when phosphorescing with sufficient intensity, can excite phosphorescence in another sample of the sulphide, although to a less degree. This phenomenon has been termed "auto-excitement", and it occurs when a flask containing a phosphorescent sulphide is exposed to light. Only the outside layer of the sulphide receives the direct light-stimulus, but it is found that the whole mass is phosphorescent, but in zones of decreasing intensity towards the centre of the flask.

From the above, it would appear that phosphorescence is governed by a variety of conditions. Summarising these it will be seen that the phosphorescence of an alkaline-earth sulphide is dependent on :—

1. The amount of impurity present.
2. The nature of the impurity.
3. The temperature of the phosphorescent substance.
4. The intensity and duration of the light-stimulus.

In the case of fluorescence, it has been shown that the phenomenon is often due to the presence of an impurity. It is really remarkable that the presence of a second substance in minute amount should impart such a striking property to the main substance. A theory which would attempt to satisfactorily explain this must be of a dual nature. It must account for the physical as well as the chemical action of the impurity.

Photo-luminescence is really a case of *light-storage*, or rather the storage of some form of light energy. If it were possible to measure the total amount of light-energy taken in by the phosphorescent substance, and also the total amount of light-energy subsequently evolved as phosphorescence, the two values would doubtless coincide. After all, the storage of energy in its various forms is not a novel idea. Mechanical energy, heat and electricity, can be stored in some potential form; why not also light?

The work of Dewar (*Proc. Roy. Inst.*, 1895, xiv., 115) on phosphorescence at low temperatures also supports this view. Most forms of energy disappear at low temperatures, in addition to being made greater by increase in temperature, and the phenomenon of phosphorescence is no exception to the rule.* Dewar found that the sulphide of the alkaline-earth metals, whose phosphorescence is increased by rise in temperature, ceased to be phosphorescent when cooled to —80° C., but on being returned to ordinary temperatures, their phosphorescence was regained. Although, at these low temperatures, the phosphorescent sulphides are unable to evolve light-energy, they are capable of absorbing it, and of releasing it at higher temperatures. For instance, calcium sulphide, when light-stimulated at a temperature of about —80° C. does not exhibit phosphorescence, but on warming up to ordinary temperatures, the usual phosphorescence is obtained. Thus light-energy, which is absorbed and stored in a potential form at a temperature of —80° C., can be completely evolved at higher temperatures. If the light-stimulation is carried out at still lower temperatures, the intensity of the resulting phosphorescence is increased.

The duration of phosphorescence varies greatly. In some cases it may last for days, whilst in others it is almost instantaneous. Besides being dependent on the duration and intensity of the light-stimulus, the duration of the phosphorescence is to a large extent governed by the intrinsic physical, or chemical properties of the body itself. From time to time, suggestions have been put forward for the construction of an instrument which would measure the duration of the light evolved by a body possessing only a short-lived phosphorescence, but only two have really materialised; they are the phosphoroscopes of Becquerel and Lennard. The former deserves a brief description.

Becquerel's Phosphoroscope consists of a shallow metal drum having two apertures cut in both ends, and exactly opposite each other. Inside the drum and near each end are place two discs which have been divided into sectors, and each alternative sector cut out. The discs are so arranged that when the sector at one end closes the aperture, light is freely admitted at the other end of the drum. Thus it is obvious that when light is admitted by a body placed in the drum, the aperture to which the eye is placed will be closed by one of the sectors, and will only be opened when a sector crosses the aperture at the opposite end of the drum. When the discs are rapidly rotated, the phosphorescent substance inside will be exposed to light and to the eye in rapid succession so as to produce a continuous vision. By this means, knowing the number of sectors and the rate of rotation, it is possible to estimate the duration of the phosphorescence of the experimental substance.

Other Types of Luminescence.

Light is not the only form of energy which can act upon bodies so as to cause them to exhibit luminescence. Luminescence due to other causes has long been known, and the phenomenon admits

*Dewar observed that many non-phosphorescent bodies, such as ivory, rubber, cotton-wool, paper, gelatine, etc., become phosphorescent at the temperature of liquid air. This apparent contradiction deserves investigation.

of certain more or less arbitrary divisions. Thus we can distinguish several classes of luminescence which are usually named according to their exciting cause. They are :—

1. Tribo-luminescence ("Luminosity by Attrition").
2. Thermo-luminescence.
3. Chemi-luminescence.
4. Crystalo-luminescence.
5. Electro-luminescence.

These subdivisions of luminescent phenomena, together with photo-luminescence (phosphorescence), and fluorescence, are all included in the generic term *Luminescence* (Wiedeman). As their cause is probably fundamentally the same, it will be desirable to deal with each class in turn.

Tribo-luminescence. — Thomas Wedgwood is generally considered to be the discoverer of "Luminosity by Attrition," although it was observed some years before by Du Fay (1735). In a paper on "The Production of Light from Different Bodies by Heat and Attrition" (*Phil. Trans.*, 1792, 17, cxxviii., 215), Wedgwood put forward the view that almost all substances possessed some latent "phosphorism" which might be made apparent by heat or by attrition (rubbing). His experiments extended over a wide range of minerals obtained from different localities, and even to this day his paper has not been surpassed for painstaking care and thoroughness by any other workers on the subject.

Wedgwood observed that the colour of the light varies according to the minerals used. He also noticed that the "bodies give out their light the instant they are rubbed on each other, and cease to be luminous when the attrition is discontinued." He paid attention to the "fœtid smell" which invariably accompanies the phenomenon of tribo-luminescence, although he offered no explanation of the peculiar odour. The cause and nature of this odour is still unknown. Quartz exhibits tribo-luminescence even under water, alcohol, or ether. This fact has prompted a writer in *Nature* (Nov. 4, 1920) to suggest that the apparently volatile odoriferous matter could probably be obtained in solution by grinding quartz under a suitable liquid. However, at present, speculation is of little use until more experimental evidence has been accumulated, for with regard to the latter, our knowledge of the subject is little more than it was in Wedgwood's time.

Thermo-luminescence; as its name implies, is the phenomenon which accompanies the heating of of certain substances to temperature below red heat. Wedgwood carried out experiments on thermo-luminescence by dropping substances on to a heated iron plate. He found them to emit "considerable light." Many bodies emit light when heated. In the case of chlorophane, a variety of fluorspar, the heat of the hand is sufficient to cause the mineral to luminesce vividly.

But here again our knowledge of the subject is almost zero. Ordinary phosporescence or photo-luminescence might very well be considered to come under the heading of thermo-luminescence, for below a certain temperature no amount of light-stimulation will cause luminescence, but on warming up to ordinary temperatures, the luminescence becomes apparent. One might postulate and determine a critical temperature of luminescence, and thus absorb the category of thermo-luminescent bodies into the larger photo-luminescent classification. Wedgwood noticed the fact that the luminescence decreased with subsequent heating, although after many periods of heating he was never able to *drive* the luminescence off, as it were. However, modern investigation would probably be able to determine whether repeated periods of heating are able to rid a body of its luminescence, and whether after light-stimulus at ordinary temperatures, the body again becomes luminescent on heating. This piece of simple experimental evidence would enable us to definitely fix our views with regard to photo and thermo-luminescence, and most probably the two divisions would become absorbed in one larger category.

Chemi-luminescence includes all cases of chemical action which give rise to luminescence without any apparent rise in temperature. The luminescent properties of phosphorous in contact with air and moisture are well known and have been carefully studied. The luminescence of decaying vegetable matter, due to the presence of luminous fungi and bacteria, have also rather prematurely been classed under this heading.

Crystalo-luminescence.—Certain salts, on crystallising from suitable solvents, give out a luminescence of short duration at the moment of crystallisation. The luminescence of arsenious acid crystallising from HCl has long been known. Berzelius noticed that saturated solution of sodium fluoxide evolved a momentary yellow-light when crystallising.

Bandrowski (CHEMICAL NEWS, 1894, lxx., 313) studied the luminous phenomena attending the crystallisation of NaCl, KCl, KBr, K_2SO_4, KNO_3 from aqueous solutions. He also observed a luminescence which occurred when salts were precipitated from the aqueous solutions by means of HCl. Sodium chloride, he states, gives a striking result, the light evolved being of a greenish-blue colour, and of considerable intensity. Bandrowski considers that luminescence is brought about by the union of oppositely-charged ions from the solution. This statement he regards as confirmed by the fact that only salts which are electrolytically dissociated exhibit the phenomenon.

Farnau (*J. Phys. Chem.*, 1913, xvii., 637) has investigated the crystalo-luminescence of the haloids of Na, K, Cd, Zn, Hg, Li, Rb, and Cs. He extends his observations to luminescence of all kinds, which he considers to be due to obscure chemical actions. If the rate of the reaction is increased by means of catalytic agencies, or by temperature, the intensity of the luminescence is increased in proportion. According to Farnau, the nature of the luminescence depends only on the metallic content of the compound, and is the same howsoever produced.

Electro-luminescence.—The circumstances under which bodies can be made luminescent by electrical means are well known, and it is in this branch of the study that most of the work connected with luminescence has been performed. Many substances, especially diamonds and rubies, become luminescent more or less readily when subjected to the action of cathode rays, X-rays, radium emanation, ultra-violet light, and other forms of radiant energy. Rarified gases also become luminescent when subjected to the action of

the cathode rays. These appear to be the only known conditions under which gases become luminescent, although Newall (*Nature*, 1897, lvi.) has apparently observed luminescent phenomena attending the compression of a gas from low pressures up to ordinary pressure.

Obviously, the phenomenon of luminescence in rarified gases is due to the operation of some kind of radiant energy, and Jackson (*Trans. Chem. Soc.*, 1894, cxxxiv.) put forward the suggestion that the colour of the sky might in reality be of a luminescent nature, the highly rarified gases existing on the fringe of the earth's atmosphere becoming luminescent under the influence of the solar radiant energy.

Such are the main departments into which all luminescent phenomena are divided. Although luminescence is the study in question, we for the most part still grope in darkness when considering it. In every branch of the study the possibilities of research are enormous, and long vistas of the unknown await the scientific man who undertakes a close and persistent investigation.

But our article would be incomplete without a short reference to the

Theories of Luminescence.

Under this heading we shall confine ourselves to a rapid survey of the theories of photo-luminescence (phosphorescence) only. As they are very numerous, and as each investigator appears to have his own particular theory, it will be convenient here to gather them up into classes or types, for each theory conforms more or less to a standard type.

Actual Absorption of a Material Light.—All early theories are based on this conception, and only differ in the explanation of the nature of the light emitted (Boyle, Canton, &c.).

Theories Involving Ionic Changes. — These theories which attempt to explain the apparently necessary presence of minute traces of impurities in phosphorescent substances, regard the phosphorescent body (alkaline-earth sulphide) as containing in solid solution a heavy-metal sulphide. By the act of solution the latter substance is decomposed into ions, which are further split up by light into electron-like particles. When these latter unite to re-form ions, light is emitted, and thus a phosphorescent state is set up (De Visser, *Chem. Centr.*, 1902, 1, x., 583; Belby, *Nature*, vol. 1904-5).

Theories Involving Chemical Changes.—This type of theory may be stated as follows: When a substance A becomes luminescent under the influence of light, it is converted into a new substance B. This latter is destroyed by heat, being converted back again into A. Thus luminescence is the energy which is evolved as a result of the transformations of the substances A and B. When thermo-luminescence does not occur, the compound B is probably of an unstable nature, and is decomposed at the instant of its formation.

By this theory, the persistence of phosphorescence after the light-stimulus has passed may be regarded as thermo-luminescence at ordinary temperatures (A. Debierne, *Compt. Rend.*, 1906, cxliii.; Wiedmann and Schmidt, *Ann. der Physik*, 1895, lvi., 246; Nichols and Merritt, *Phys. Rev.*, 1908, xxvii., 367; Voigt, &c.).

Electron Theories.—In these theories it is supposed that under the influence of light, electrons are emitted from the phosphorescent body. The electrons, however, are only evolved from certain "centres," and not uniformly from the whole area of the alkaline-earth sulphide exposed to light. The areas or localities from which the electrons have been liberated now acquire a positive charge of electricity, whilst the electrons themselves become attached to the sulphur atoms. It is in the return of the electrons from the sulphur atoms to their original "centres," and in the subsequent neutralisation of charges that the phenomena of phosphoresana has its rise (Lennard, *Ann. der Physik*, 1910, xxxi., 675; Stark, *Prinzipien der Atomdynamik*, 1911; Allen, "Photo-Electricity," 1913).

Although most of the theories may be referred to the above types, the list is by no means exhausted. However, space doos not admit of any one of them being treated in detail. The most rational and far-reaching explanation of phosphorescence will probably be based on the belief held towards the end of the last century, that in some manner, light or some accompanying-light energy is held by the substance in the form of a *strain* of energy, and that during a recovery from the strain, light is emitted, in much the same way as energy can be stored in the form of a strain, by twisted elastic cords. Klatt and Lennard added substance to this view by showing that the alkaline-earth sulphide entirely lose their property of phosphorescence when subjected to high pressures.

But here we must leave the subject as it stands. A complete understanding of the phenomena involves a knowledge of the play and interplay of atomic forces; a knowledge of which is yet lacking, but towards which the physicist is slowly but surely groping his way. Meanwhile, much remains to be done in revising and placing on a firm scientific basis many observations, the accuracy of which is to be doubted. The varied phenomena of luminescence should cease to be regarded as scientific curiosities, but should more properly be looked upon as manifestations of some unknown natural law.

SOME TECHNICAL APPLICATIONS OF SPECTROSCOPY DURING THE WAR.

By A. de Gramont.

Some years ago, the author showed that the spark discharge of an electrostatic condenser when it illuminates the surface of a solid or fused compound gives a complex spectrum in which *all* the constituent elements of the compounds exhibit their individual line spectra. The spectrum thus produced may be considered to be obtained by the super-position of the spectra of the compounds, in which, of course, the stronger rays of one element may eclipse the fainter lines of another element in their immediate neighbourhood. The spectra of compounds thus give time dissociation spectra in which all the substances present can be recognised, the sensibilities being different according to the element under consideration. The apparatus used by the author consisted either of a spectrograph with two crown glass "uviol" prisms, or one with a single quartz prism, the former giving the best results. When the substance under examination consisted of a non-conducting

material, such as a precipitate or powder or earthy mineral, a suspension of it in a fused alkaline salt was made. Certain rays which the author called "ultimate rays" were found to be always the last to disappear as the amount of the element was diminished. These rays are not necessarily the strongest or brightest in the spark spectrum; they are found in the arc spectrum and in the spectra of very hot flames, such as the oxy-hydrogen or oxy-acetylene flame. Certain metalloids, such as chlorine, bromine, iodine, oxygen, sulphur, selenium, and nitrogen, do not give arc spectra nor ultimate rays, while others, such as boron, carbon, silicon, phosphoric, arsenic, tellurium, exhibit these rays, and although their detection by spectrocopy is not easier than by modern analytical methods, it is very usefully employed in the case of the co-existence in a compound of several elements. The ultimate rays of these metalloids are situated in the very refrangible part of the ultra-violet.

The author applied this method of investigation to many metallic products, and drew interesting conclusions as to their purity. He found that *some specimens of German steels, for example*, gave extremely complex spectra, showing the presence as essential constituents of chromium, nickel, vanadium, and tungsten. Minute traces of boron in a vanadium steel make it extraordinarily hard. So-called pure specimens of copper always contained iron and carbon, and often calcium and silver. Commercial platinum contained copper, silver, and gold, as well as iridium, rhodium, and palladium, while zinc always contained traces of cadmium, lead, and iron. An interesting discovery made by the help of this method was the fact that the ash of tissues and various physiological products always contains zinc, and it has been established that zinc is a normal constituent of all animal cells.—*Bulletin Officiel de la Direction des Récherches Scientifiques et Industrielles et des Inventions*, July, 1920.

A CRITICAL STUDY OF FERTILISER EXPERIMENTS.

By C. B. LIPMAN and G. A. LINHART.

Among the most expensive and time-consuming experiments in agricultural investigations have been those which attempt to ascertain the proper chemical amendments or fertilisers for soils. This applies in particular to the long-term fertiliser experiments like those at Rothamsted in England, at State College in Pennsylvania, and at Wooster and Strongsville in Ohio. Conceived and inaugurated, as they were, at times when little or no real authentic information was available relative to the nature of soils and plants, it is but natural that fallacious and short-sighted planning should have dominated them. It occurred to one of us that as critical thinking in this field has become more general, and facts more plentiful, it is high time that fertiliser experiments in general and the "long-term" experiments in particular be subjected to critical scrutiny. It seemed desirable to employ the statistical method for this purpose, particularly in view of the striking results obtained in this laboratory by our former associate, D. D. Waynick. It seemed clear to one of us that if, as Waynick, and Waynick and Sharp had demonstrated, the variability of soils and of plants is very large even within selected and presumably uniform material, one could not expect previous fertiliser experiments to be of much value, since the factor of variability has been entirely ignored in their arrangement and study, and the probable error to which they were subject was not determined. Accordingly, Lipman and Waynick began in January, 1919, a systematic study by statistical methods of the results of fertiliser experiments at the Ohio and at the Pennsylvania Agricultural Experiment Stations. Mr. Waynick left this laboratory the following July, but with a number of interruptions, the work has been continued, and we hope to issue the voluminous data, together with a critical discussion of them, in due course. Since the work may be a long time in the press, we deem it wise to present here a few of the salient and most important findings of our studies, so that our colleagues may be apprised of what we consider to be an investigation of a fundamental nature, not merely on account of the importance of the subject itself, but because of its important bearings on agricultural research.

It seems that the originators of both the Ohio and the Pennsylvania experiments saw the value of replicating check plots, while not recognising the value of such replication for the treated plots. Only in the case of two complete fertiliser plots in the Ohio experiments, was the fertiliser treatment the same. In all the others every treatment was different from that of every other. This situation renders it difficult to subject their data to statistical treatment in the most desirable way. Fortunately, however, the long series of years during which the plots were studied gives, in a certain sense, a replication of plots of each kind. Our procedure has been, therefore, to group the plots in different ways, including the following:—

1. All the check plots for each year.
2. One check plot for all the years.
3. All the plots treated with "one-element" fertilisers in one year.
4. Every "one-element" fertiliser plot for all the years.
5. The same double study for the "two-element fertiliser plots."
6. The same for the "three-element" fertiliser plots.

In addition to these groupings, others were made in which a given plot was studied with each crop in the rotation, so as to allow of only three to eight "yield" data for each plot. It may be said in passing that the rotation study included in these experiments only serves to complicate a situation which was already sufficiently difficult. We shall show in detail in the complete study which is to be published, that these experiments are utterly inadequate for solution of the questions involved, and that all such fertiliser experiments are so fallacious as that they do not justify the use of the large amounts of money that are constantly being lavished upon them.

For the sake of brevity, only a few of our findings, from the study of the Ohio data alone, are summarised here.

1. The "one-element" fertiliser treatments show no significant increases in yield over the yields

obtained on the untreated check plots. All statements to the contrary which have heretofore been made are erroneous, and the data on which they are based were obtained by a misleading method of procedure and evaluation.

2. The "two-element" fertiliser plots give definite increases in yield over the untreated control plots. Whether or not the increases are profit-yielding, however, is a question which will be discussed later.

3. The "three-element" fertiliser plots give definite increases in yield over both the untreated control plots and the "two-element" fertiliser plots. Here again, the question whether the increases are profit-yielding still remains to be determined.

4. The kind of fertiliser used seems to have been without significance, one being just as good as another, subject to the limitations above noted.

5. The amount of fertiliser used seems likewise to have been without significance (subject to the same limitations).

6. Even when fertiliser experiments are properly planned, and the results adequately studied by statistical methods, our present knowledge of the enormous variability of all soils and plants renders the data from any given fertiliser plot of value only on that plot, no matter how near the experimental one. This important consideration renders it highly probable that no fertiliser experiment as ordinarily conducted is possessed of sufficient practical value to justify the large expenditure of money, time, and energy involved.

We wish to emphasise that we are not desirous of making a fetish of the application of statistical study to fertiliser experiments. Nevertheless, we must say that if statistical methods, inadequate as they may be, should not prove applicable to an evaluation of the results of fertiliser experiments the latter must be accounted of even less value and significance than we have here accorded to them.—*Proceedings of the National Academy of Sciences of U.S.A.*, November, 1920.

ELDRIN, A NEW PLANT CONSTITUENT.*

By JOHN URI LLOYD, Ph.M.

For thirty or forty years in the experiments I have made with drugs, plants, and plant structures, I have met continuously the fact that linked with each plant texture there was something present that under the influnce of an alkali gave a yellow colour. For example, strip a paw-paw of its bark and touch the white inner surface with a solution of potash—now it turns yellow. There is probably one rule in this as elsewhere, and that is the rule of exceptions. I hope to find one white blossom that will not turn yellow. If I do, the exception may be of help to the botanist, for it may be the forerunner of a class distinction.

For years this yellow phenomenon was before me, but I could not catch the material that produced it. About a year-and-a-half ago I decided that if I isolated this yellow something that pervaded all plant tissues so linked with imprities as seemingly to defy isolation, it must be obtained from something that is white, something that does not carry a mass of extraneous material to contaminate the principle desired. Then it occurred, why not use the petals of a *white* flower to get this *yellow* something?

The elder was then in bloom. These, I found, turned deep yellow with ammonia gas. I procured 50lb. of elder flowers, put them in a percolator, made a tincture, and worked it by means of neutral solvents and excluders, to rid the product of the alcohol, chlorophyl and wax. I had 5 gallons of the chlorophyl-free liquid, and said to Mr. Miller, who was assisting me: "Place the jar in a cold situation, and to-morrow morning I shall examine it." Next morning I tipped the jar very carefully, and all down the sides were little white concretions about the size of pin heads. It was the thing I have been seeking forty years.

I took one of those pin heads to the laboratory and dropped it into distilled water and it did not dissolve. I added ammonia—behold! it immediately dissolved, the liquid turning deep yellow. It was only the size of a pin head, but there were thousands of them. An they kept increasing in size. The marvellous phase of this subject is, I got 11oz. (crude) of that substance out of that 50lb. of elder flowers. Before that, by reason of faulty research, I could not get a grain from anything.

The first thought of a pharmacist is, what value a new substance may have in medicine. Alas, the greater part of my work has been the repeated finding of something that had no value. I sent some of this material to Prof. R. Adams Dutcher, University of Minnesota, requesting that he make a physiological examination of it. His preliminary report was to the effect that, according to a preliminary investigation, it had no physiological action. May I not ask, should a peculiarity of action be expected of a substance pervading plant tissues everywhere. (I had vitamies in mind, there was reason to hope that a general life supporter of plant life, serviceable to animals, could be found and isolated. Not a poison of energetic action. This, I accept, Dr. Dutcher demonstrated as a fallacy in the direction of this substance).

In this cylinder I have distilled water, and I propose to put into the water a small amount of this material. Note that it settles to the bottom. It is perfectly insoluble. One grain shaken with a gallon of water apparently disappears, but if let stand until the next day, behold, it is all at the bottom. I now shake the mixture, and pour half of it into another cylinder, then add a little ammonia water—note the change in colour, to deep yellow. A very delicate reagent is it for an alkali. Let us now make both liquids yellow. Into one I pour diluted sulphuric acid, in excess, to destroy the ammonia. The liquid becomes colourless.

Now the question came to me, "Why is the white flower white when it has the yellow material in it in such quantity?" Then I figured to myself it must be because the white petals carry also an acid which in contact with the yellow material makes it white. In other words, would the white flower be yellow if there was an alkali in the petal instead of an acid? Crushing the flower in a mortar with a little distilled water gave a sharp acid reaction. Blue litmus turned red at once. The acid was present.

*Portion of an address on Plant Constituents delivered at the Ohio State Eclectic Medical Assoc. From the *Eclectic Medical ournal*, Dec., 1920.

The question arises: What is the use of this thing in nature? I think I comprehend the subject, but it is too great to try to bring before you to-day.

I am going to ask you to be charitable in what I have said concerning the theories I now hold. I may be right and I may be wrong. We can see this colour change and we know that the petals hold organic acid. What of it? I don't claim that anything I have brought is new; quite the contrary. So far as I know, this experiment has not been made. In some literature unknown to me it may be explained. It doesn't matter whether it is new or old—it is a phase in plant economy that is a fact, and may be of service other than as a medicine.

I asked myself: Why the material could not be used to make a test paper? Why would not paper saturated with a solution of this material turn yellow with alkali and colourless with acid? I tried it and it worked. There is a shade between red and blue litmus which makes it difficult sometimes to quite determine the end-reaction. There is no intermediate shade with this.

For example, let us now pour into these tumblers some water, and into the one put some ammonia and in the other dilute sulphuric acid. The paper I hold in my hand has been saturated with a weak solution of this material and dried. I dip it into the acid. See, it is colourless. Now I dip it into the ammonia; it instantly turns yellow.

You ask the name of this material. I call it *Eldrin*. But it may have been long known elsewhere and recorded under a different name or different terms.

AN EPOCH-MAKING DISCOVERY.

By Charles. H LaWall, Ph.M.

It is bromidic to quote the oft-repeated proverb about the prophet and his own country, and yet none other is applicable to the situation in which Einstein finds himself in Germany while much of the remaining scientific world is doing him homage and dscussing his work on "The Special and General Theory of Relativity."

This is an age of pragmatism, and while the educational attainments of the average individual are higher than ever before in the world's history, it is to be doubted whether there is much sympathy with, or consideration of, abstract principles as a rule, except among mathematicians and physicists.

From the earliest times there have been those who went out of their way to grapple with the unknown, whether or not the rewards were apparent. Babylonian arithmeticians and Egyptian geometers had exercised their mathematical abilities chiefly along the lines of mensuration, with some attention to astronomy, but when the speculators of Hellenic origin appeared, abstract mathematics became a cult which lasted for several centuries, and which influenced human though for all time. Thales, Pythagoras, Plato, Euclid, Aristotle, and Ptolemy, were little concerned with the practical applications of their theories, yet they paved the way for Copernicus, Descartes, Galileo, and Newton, who came many centuries later.

The pupil of Euclid who asked "What do I get for learning these things?" typified a state of mind common to all ages, and probably approaching its highest peak in our own time, as indicated by the general apathy with regard to the underpaid members of the teaching profession, and the attitude of the average school pupil or college student who aims not at perfection in his work but sets his goal at the minimum passing grade.

In Francis Bacon's classification of human knowledge (1630) speculative philosophy occupied a larger proportion of the diagrammatic scheme than would be accorded it by one who attempted a similar outline to-day, and yet the worker in pure research, or the one who discovers and records an abstract scientific principle, may be conferring upon future generations blessings incalculable.

The continuity of scientific effort in any single direction is more evident in our era than at any previous time in the world's history.

More than two thousand years elapsed between the crude steam appliances of Ctesibus and Hero, and the steam engine of James Watt, and outside of one experiment of Leonardo de Vinci, most of the developmental work occurred in the century in which Watt himself lived.

It took comparatively few years for the discovery of the Hertzian waves to find their practical application by Marconi, and yet Hertz and his co-workers never dreamed of such a thing as wireless telegraphy, nor profited by their work except in reputation.

The work of Albert Einstein, which deals particularly with space and time, and which concerns itself in reality with a method of interpretation of old rather than the promulgation of new principles, is looked upon as epoch-making in its possibilities by some of the mathematicians, physicsts, and philosophers, who are in close enough touch with the subject to be able to judge thereof intelligently.

For the individual not actively engaged in the fields of work most directly affected by Einstein's observations, articles have appeared; lectures have been delivered and books have been written for the purpose of stopping down the high voltage of the original communication to a lower potential which will not burn out the mental coils and fuses of the average intellect. Dr. Leffmann has humorously and approximately correctly translated the Einstein idea into the epigrammatic form that: "You cannot tell where you are unless you know what time it is and you cannot tell what time it is unless you know where you are."

In Euclidean geometry, as taught in our elementary schools, descriptions of events in space presuppose the existence of a rigid or invariable body to which such events may be referred.

No cognizance is taken of differences of values in observation, due to the fact that one observer is in motion while the other is at rest, nor of differences in interpretation due to time discrepancies.

In physical science data have long been accumulating for which no use could be found in the calculations of three dimensional or ordinary space. By the introduction of the time factor a four dimensional space-time combination becomes possible, and these hitherto unused data are said to find a place.

In the Einstein method of interpreting mathematical and physical data, the length of a

measuring unit or of the duration of an event are not absolute quantities, as has always been hitherto assumed in physics, but it is declared that they actually have different values for different systems of reference moving with relation to one another.

Newton had established concepts of what it has been customary to call "Absolute true and mathematical time" and "absolute space."

Experiments of certain physicists had proved man's inability to detect absolute motion (motion with respect to the hypothetical æther). This has recently led to the development of a theorem to the effect that "all laws of physical nature should have been formulated with reference to a definite coördinate system, are valid, in precisely the same form when referred to another coördinate system which is in uniform rectilinear motion with respect to the first."

This empirical law is Einstein's "Special Theory of Relativity."

It is a simple matter to make time duration calculations with a clock situated where the event is taking place. It is more difficult to make such calculations with events happening at two different places, for then some elaborate precautions must be taken to bring the two clocks into synchronous agreement. When we come to deal with calculations where the clocks are not at rest with reference to each other, as for instance, when one is on a railway train travelling at a high rate of speed, all ordinary methods of measurement and comparison fail.

Such refinements of observation seem to be beyond our conceptions of practicality, and yet we are assured of their value by those who deal with calculations involving the physical laws, particularly with reference to light.

One of the modern concepts, which is at variance with Newtonian principles, is the declaration that a gravitational field has an influence upon a ray of light. Einstein asserted his ability to prove this by the application of his method to observations and calculations of certain astronomical phenomena. This assertion is said to have been confirmed by observations of the photographic registrations of stars during the eclipse of the sun in May, 1919, and afford justification for the hope that some of the obscure laws of nature may be fathomed by a further pursuit of this subject by those philosophers who are equipped for this recondite branch of human study.

In the words of one of the recent interpreters of Einstein to the multitude this thought is expressed as follows: "The main philosophic achievement of the special theory of relativity is probably the recognition that the description of the event, which is admittedly only perfect, if both the space and time coördinates are specified, will vary according to the relative motion of the observer; that it is impossible to say, for instance, whether the interval separating two events is so many centimetres and so many seconds, but that this interval may be split up into length and time in different ways, which depend upon the observer who is describing it" ("Space and Time in Contemporary Physics," by Moritz Schlick).

The "general theory of relativity" concerns itself with the broader fields of human speculation and endeavour. This is much more daring and less easily comprehended without a knowledge of higher mathematics and there are those among the physicists and mathematicians who characterise it as "Metaphysical Mathematics," and "Intellectual Moonshine."

The fundamental question, "are space and time real?" cannot be answered simply and categorically. Space and time for human comprehension and appreciation are dependent upon the existence of things which lie closer to our senses.

If there were not material bodies we could have no conception of "space", and if no events or changes took place "time" would be devoid of meaning. The world-old question as to what constitutes reality finds the answer of the modern physicist eminently satisfying. "Whatever can be measured is real."

Are space and time real? Both being measurable we unhesitatingly reply in the affirmative. Yet if we perform the imaginary experiment of the celebrated French mathmatician Poincaré, and "suppose that all material bodies should increase over night one hundred fold," we should be unable to perceive the change, for all of our measurement standards and units would have changed likewise. We should still call an inch by that name although it had increased to more than eight feet. How can we argue convincingly about the reality of space, therefore, except as a relative concept.

So in the same way our time determinations become closely associated with physical bodies as our ideas of space, and quantitative determinations are predicated upon some pre-arranged method of synchronising our clocks; otherwise conceptions of simultaneity and equal duration can have no definite and invariable meaning.

The influence of the gravitational field prevents the application of the special theory of relativity to any but systems at rest or moving uniformly and rectilinearly.

The mathematical development of the theory pre-supposes the introduction of the time factor as a fourth coördinate and calling the new and complex curve thus produced the *World-line* of a given point. The final formulation of the Einstein Law is expressed as follows. "The world-line of a material point is a geodetic line in the space continum." The time factor is not introduced simply as such, but as $ct = x_4$ in which c denotes the velocity of light.

The statement that every motion is relative may be looked upon as another way of expressing the view that space and time have no physical objectivity. Space and time are not measurable in the abstract. They constitute the framework which we fill up with physical events, both spatial and chronological.

We gain our knowledge of both space and time by direct experience, so in our everyday life we shall continue to deal with them as heretofore. To the physicist and astronomer, however, new fields of research are already opening, and it is not too much to expect the future to bring us into closer harmony and a more nearly correct understanding of electro-dynamics and gravitational law with a realisation, perhaps, that matter after all is but one of the manifestations of energy.

One comfort for the average student of mathematics is found in the assertion that "Euclidean geometry is to remain valid for infinitely small portions" which includes those within the ken of our ordinary daily life. The trouble with the

whole subject at present lies in the fact that Einstein enthusiasts are presuming to "prove the unprovable", and to make assertions to the effect that there is such a thing as "finite space without boundaries."

Students of philosophy who remember the speculations of Kant in his "Subjectivity of Time and Space," and Locke in his "Essay on Human Understanding," and Leibnitz, the originator of differential calculus, will enjoy the spiritual exhilaration of cleaning out the cobwebs of the mental attic, by reading one of the works which have recently been published in which the subject is discussed with a minimum of complex mathematical details, although it will be realised that workers in physics are rapidly ascending to heights in which the rarefaction of the mental atmosphere will soon make it impossible for the person of ordinary education to accompany them, and in which they will be invisible to those below the cloud strata of higher mathematical formulas.—*American Journal of Pharmacy*, January, 1921.

PROCEEDINGS OF SOCIETIES.

THE OPTICAL SOCIETY.

At a meeting of the Optical Society, held at the Imperial College on March 10, Prof. H. F. Newall, F.R.S., gave a lecture on "The Story of a New Star". Available data relating to the known history of several novæ were reviewed, and the interpretation of these discussed, with a view to the formulation of a theory on stellar evolution.

Mr. T. F. Connolly, M.Sc., described and exhibited "A Handy Form of Measuring Microscope." The instrument uses a microscope system of relatively low power. A double image prism traverses the object space, and is controlled by the rotation of a milled band operating a spiral slot. Exit pupil discs of telescopes or other optical instruments and Brinell impressions can be measured by a single contact setting of the edges of the duplicated discs. The range in the experimental instrument is from 1 to 6 mm., and the accuracy when used with a fixed focus for Brinell impressions is about ± ·02 mm. The reading scale is very open, and is divided to one-tenth mm. No vernier is used.

NOTES.

The Sir John Cass Technical Institute.—The Fourth Annual Dinner of the Department of Metallurgy was held at the Florence Restaurant, Rupert Street, Piccadilly, on Saturday, March 12. George Patchin, Esq., A.R.S.M., M.I.M.M., Head of the Department, was in the Chair, and the company of more than 100 included present and past students of the Department, the staff, and a number of distinguished guests. Among the latter were Prof. Merrett, of the Royal School of Mines, Richard Davies, Esq., C.B.E., and J. G. Howell, Esq., of the Governing Body of the Institute, and Dr. Charles Keane, Principal of the Institution. The most important event of the evening was a presentation to C. O. Bannister, Esq., A.R.S.M., F.I.C., who, after 18 years' work at the Institute, has been appointed First Professor of Metallurgy at the University of Liverpool. This was in the form of a silver coffee service, designed by Mr. Harold Stabler, and executed by Mr. W. E. Stocker, of the Art Department of the Institute. Prof. Merrett, in proposing the toast of the department, referred to the continued development of the Department since the war, as shown by the increase both in the number of courses, and in the number of students, the latter numbering 138 in the Session 1919-20. He suggested the addition of a course on ore dressing would give greater completion to an already comprehensive curriculum.

British Industries Fair.—While it is impossible at the present stage to give any estimate of the total business resulting from the British Industries Fair at the White City, certain general conclusions may be drawn from the information at present available. Considering the severe and universal nature of the present trade depression, the bookings in most sections of the Fair may be regarded as satisfactory. The results are, however, difficult to give in any concrete form since no one section has enjoyed uniformly large orders, nor any other suffered from uniform lack of orders. It is noticeable that there are many cases of individual firms doing exceptionally heavy business, but throughout the Fair as a whole, business was considerably below that of last year. When, however, the widely different conditions of trade are considered, this fall in orders booked does not mean so great a drop in the actual business transacted, since last year the buyer was giving orders much in excess of his requirements in the hope of securing those requirements from a short stocked supply, whereas this year any orders booked are definite and final contracts. The attendance at the Fair was also highly satisfactory, nearly 65,000 people visiting the White City. Overseas buyers came from fifty different countries, from Chile and China, from Sweden and Singapore. While the bulk of the foreign buyers came from Europe, Holland, Switzerland, Belgium, and Scandinavia being specially well represented, the attendance from the Dominions was also considerable, and many American visitors were seen at the White City. One unexpected feature of the Fair was that, while the luxury trades could not have been expected to enjoy large orders under present conditions, yet many firms producing the highest grade articles received very considerable orders, in some cases even exceeding last year's. The general organisation of the Fair proved satisfactory, and many spontaneous tributes to its smooth working were given by both visitors and exhibitors.

Birmingham and Glasgow Sections.—It is understood that the general results of the Birmingham section were well up to expectations, and Glasgow is reported to be doing well, particularly in certain lines of textiles. The visit of H.R.H. the Prince of Wales to the latter section on Tuesday was greatly appreciated by the exhibitors, and helped immensely to stimulate interest in the Fair.

Foreign Missions.—The visit of the Foreign Commercial Missions as guests of the Government has been an unqualified success. During their

he three Fair centres and their reception hester, the delegates have enjoyed every or a rapid and thorough survey of British The fresh connections formed by the of the Missions with the leading repres of the trades of this country should be re of much fresh business and increasrmonious commercial relations between :d Kingdom and the Continent.—*Board of ournal*, March 10.

ND-CUTTING SCHOOL IN SOUTH AFRICA.—g to the local press, a school for training women in diamond cutting is shortly to lished, probably in Johannesburg. The l Provincial Council has voted £15,000 purpose, which will provide for suitmises and machinery, a highly-skilled head, and competent assistants. In the of a member of the Provincial Council, l should be completed by about the end One of the drawbacks to the establisha diamond-cutting industry in South the past has been the alleged absence of out with the establishment of this school, ill teach the work thoroughly and coml all its branches, there should be nothing t the building up of a large and flourishtry.

)WNED ARSENIC IN QUEENSLAND.—Among ng enterprises of the Queensland Govern-n arsenic mine, from which about 3,000 re have so far been obtained at a gross re of some £17,000. The ore is passed enic treatment works, also owned by the ose aim is to afford relief from the very es ruling for arsenical products. During financial year, the gross expenditure on was £14,040, bringing up the total since encement to £23,311. The arsenic prodistributed among the farmers of the £10 a ton for the destruction of prickly l at £23 a ton for cattle dips and other uirements.

FFS (IMPORT REGULATION) ACT, 1920.—of products covered by the Dyestuffs (Imulation) Act, which has been drawn up iltation with the Dyestuffs Advisory Committee, is now available, and may ed on application either to the Board of ndustries and Manufactures Department, eorge Street, Westminster, London, r to the Dyestuffs Advisory Licensing e, Board of Trade, Danlee Buildings, g Gardens, Manchester.

BUTION TO STUDY OF THE MECHANISM OF ILISING ACTION OF SULPHUR.—A certain of researches have demonstrated that f sulphur, applied to the soil in suitable , act as a fertiliser and increase yields. e essential elements in plant life, sulphur least a double action. In the first place s sulphuric acid, by bacterial oxidation l, directly assimilable, presence of which in non-calcareous soils, permits absorpcertain mineral elements (potash, iron umina, and even manganese). Then it the work of ammonia bacteria and nitriteria, thus placing larger quantities of at the disposal of the plants. Such are the facts acquired by experiment. It has even been thought that sulphur favours development of nodosities in the roots of leguminous plants. Experiments made in Algiers in 1918 and in the Jardin des Plantes of Nancy in 1920 to elucidate this question, with peas, haricots, *Lathyrus Ochrus* and *Lupinus Albus*, grown in pots containing sulphurised soil in the proportion of 100, 200, 300 kilogrms. of sulphur per hectare gave no clear results, perhaps because the sub-soil of mould was rich in nitrogen. These experiments demonstrate, once more, the fertilising action of sulphur as illustrated by the following figures for the haricot Souvenir de Dreuil :—

	Number of Seeds.	Weight. Seeds. grms.	Weight. One Seed grm.
Without sulphur ...	13	4·9	0·376
100 kilogrms. of sulphur	12	5·310	0·462
200 kilogrms. of sulphur		5·745	0·574
300 kilogrms. of sulphur		5·115	0·426

are interesting chiefly from another point of view. They demonstrate that in suitable proportions sulphur can favour carbureted nutrition of plants. In suitable proportions, variable with each species (200 kilogrms. per hectare for haricots and 300 for peas) sulphur favours formation of starch and photo-synthetic action, the latter being the consequence. Messrs. Mazé and Demolon have already demonstrated that sulphur is necessary for development of chlorophyll, its absence causing chlorosis. In consequence of this action on the green pigment, decomposition of atmospheric carbonic gas is stimulated, carbon is fixed in larger quantities and reserved in form of starch. Researches on the gaseous exchanges of assimilation would probably confirm this assertion. Thus, according to these observations, in addition to the value of sulphur as an aliment in form of sulphuric acid and catalytic agent in assimilation of soil nitrogen, we may add the influence, also essential, exerted on fixation and atmospheric carbon in consequence of its action on chlorophyll. Owing to this multiple action, its employment in agriculture deserves exhaustive study.—*Comptes Rendus*, January 3, 1921.

CATALYTIC HYDRATION OF NITRITES.—Nitrites, as is known, can be prepared by ctalysis of a mixture of an acid and ammoniacal gas, in contact with a dehydrating catalyser like thorine or alumina. The same reaction also occurs with ether salts in which the group CO loses its atom of oxygen which forms water with ammoniacal gas. Now we know that a catalyser will accelerate the speed of a reaction; it also accelerates the inverse reaction. One might, therefore, think that nitrites would undergo catalytic hydration in contact with thorine and alumina, and be thus transformed into acid $RCN + 2H_2O = RCO_2H + NH_3$. This was demonstrated in experiments made by M. A. Mailhe.—*Industrie Chimique*, January, 1921.

PRICE OF THE UNIT OF NITROGEN IN CHEMICAL MANURES IN SPAIN.—The *Informacion Agricola* gives the following observation in favour of Chile nitrate. The difference in the effects of various nitrogenous fertilisers equally rich in nitrogen are not comparable considering that the nitrogen in some, like nitrates, is better utilised by plants, not undergoing any transformation before being

assimilated, nor losses in the soil through decomposition and the atmosphere, whereas in fertilisers which contain nitrogen in ammoniacal form, or other more complex forms like cyanamide, the losses are considerable, and thus with equal percentages the effects of nitrates are greater than those of other nitrogenous manures. Consequently, the prices of nitric nitrogen is always greater than ammoniacal nitrogen. Nevertheless, existing circumstances in the markets make the nitric nitrogen of nitrate of soda the cheapest in Spain. Taking the quotations in the markets of Valencia and Barcelona, for all the nitrogenous chemical manures we have nitrate of soda, 4 pesetas; granular cyanamide (only practical form of this fertiliser), 4·47 pesetas; sulphate of ammonia, 4·63 pesetas; nitrate of lime, 5·04 pesetas. To make this calculation, we took the average guaranteed percentages of all of these fertilisers, viz., 15 to 16 for nitrate of soda, 19½ to 20½ cyanamide, 20 to 21 sulphate of ammonia, and 12 to 13 nitrate of lime.—*Revista Minera*, January 8, 1921.

VANADIUM IN STEEL.—A method for analysis of vanadium in steel, by M. E. Jaboulay is as follows. The metal being dissolved in sulphuric acid, the vanadium, and eventually chromium, are transformed into vanadic and chromic acids by potassium permanganate. Chromium, if necessary, can be titrated with ferrous sulphate and permanganate. The vanadium is estimated by adding small measured quantities of ferrous sulphate to the solution to a slight excess. When a blue colour appears, all the vanadium is in form of hypovanadic sulphate, and the solution contains a slight excess of ferrous sulphate, which must be destroyed, so as to only leave as reducing compound the hypovanadic sulphate, easily titrated with a permanganate liquor. The ferrous sulphate is destroyed by an excess of potassium bichromate. The chromic acid thus produced acts slowly on the greatly diluted hypovanadic acids, and titration can be made with permanganate before it exerts its oxidising action; however, titration should be promptly made after addition of bichromate.—*Génie Civil*, February 5, 1921.

RESEARCHES ON THE ACTION OF GUANOL.—Guanol is a fertiliser obtained by methodic fermentation of peat bathed with vinasse from distillation of beet molasses, under the action of micro-organisms, which produce ammonification of the nitrogenous elements (especially betain). The product is then dried; it contains 3·5 per cent nitrogen, and 7 to 8 per cent potash. Results of experiments demonstrate that (1) the effects of guanol are very slight in pots, being about equal to percentage of nitrogen in the fertiliser; (2) In the case of potatoes, in a clay soil, 6 parts guanol gave an increase of 28·7 in the crop; (3) There was no favourable effect with beet in heavy clay soil. Thus the action of guanol is not clearly specified, and new researches are necessary.—*Chimie et Industrie.*

CHEMICAL MECHANISM OF THE ASSIMILATION OF CARBONIC GAS BY GREEN PLANTS.—The existence of hydroxylamine in leaves is made certain by transformation of the ammonia into oxygenated compounds of nitrogen and *vice versâ*. These transformations comprise numerous intermediary compounds. Hydroxylamine must figure in this double series because the phenomena of oxidation and reduction realised by the living cell occur gradually, and only regard a single atom of oxygen in each stage. The experimenter, M. Mazé, has not succeeded in bringing hydroxylamine into evidence in nitrifying or denitrifying mediums. This does not mean, however, that this will not be done by aid of a suitable device. It is probable that hydroxlamine combines with the aldehydes and cetones to give oximes, and it is by virtue of this property that it acts as examination of facts shows. The existence of hydroxlamine is also shown by the constant presence of free nitrous acid and that, rather frequent, of hydrocyanic acid, two derivatives of oximes.—*Comptes Rendus*, January 17, 1921.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

6897—Du Pont de Namours & Co., E. I.—Cellulose ester compositions. March 2nd.
6783, 6784—Eustis, A. H.—Recovering sulphur dioxide from furnace gases, etc. March 1st.
6679—Grainger, J. E.—Apparatus for drying solid chemicals. Feb. 28th.
6686—Hansford, J. B.—Apparatus for drying sulphate of ammonia, etc. March 1st.
7045—Kelly, A.—Manufacture of borax and boric acid. March 3rd.
7830—Caspari, W. A.—Manufacture of benzene mono sulphonic acid. March 12th.
7906—Dieenthalero.—Manufacture of molybdenum metal or its alloys. March 12th.
7597—Goldschimdt, V. M.—Manufacture of magnesium chloride. March 9th.
7879—Jones, B. D.—Production of alkali pentaborates direct from boron ores. March 12th.
7569—Little Inc., D. A.—Cellulose derivative and process of preparing same. March 9th.

Specification published this Week.

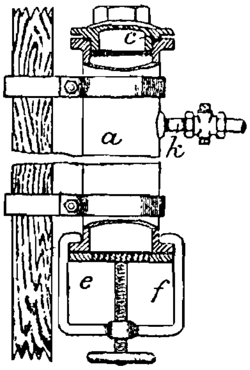
147530—New Jersey Zinc Co.—Production of metal oxides and other compounds of metals.
159337—Pascal, P.—Process and apparatus for the manufacture of liquid sulphurous acid from dilute sulphurous acid gas.
136158—General Chemical Co.—Production of oxides of nitrogen and a catalyzer therefor.
143260—Lilienfield, L.—Process of manufacture of dialkylsulphate.
159568—Ballantine, W. B.—Production of ferro-chrome alloys.
159587—Bolton, E. R. and Lush, E J.—Neutralisation of fatty acids in fats and oils.
159659—Collins, J. J.—Purifications of tin or the production of tin salts from crude tin.
139470—Kilburn, B. E. D.—Removal of iron from solutions of aluminium nitrate, sulphate or chloride.
145709—Krupp Akt. Ges. F.—Process for producing low carbon ferro-chromium.
152643—Zack, M.—Processes for separating oxygen and nitrogen and apparatus therefor.

Abstracts Published this Week.

Acetic Acid.—Mr. H. Dreyfus of Pall Mall, Westminster, has obtained a Patent No. 156916 for an improved process of obtaining acetic acid. The ferric oxide employed as a catalyst in the manufacture of acetic acid by the oxidation of liquid acetaldehyde, is prepared by precipitation from a ferric salt solution, followed by heating to a temperature between 310-500° C. Its catalytic activity is stated to be enhanced thereby. Sodium acetate may be associated with a ferric oxide but only in a quantity not exceeding about double the amount of ferric oxide present

Sulphuric Acid.—Mr. P. Parrish and the South Metropolitau Gas Co., of Old Kent Road, have been granted a Patent No. 156328 for an

improved process and apparatus for obtaining sulphuria acid. Sulphuric dioxide is bubbled through nitrous vitriol near the surface, the depth of seal not exceeding.4in. The apparatus shown comprises a tank *a* divided into compartments by partitions *b* supported on columns *c* and having serrated lower edges as shown in Figure. Sulphur dioxide is passed in at one end at *e*, bubbles through the liquid under the serrated edges and escapes at the other end at *f*. Stirrers may be provided below the level of the partitions.



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THE CHEMICAL NEWS.

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SRIVASTRA'S HYPOTHESIS:* A CRITICISM AND AN APPRECIATION.

By H. T. F. RHODES.

SOME difficulties of the electronic conception of the constitution of matter have been, from the beginning, evident; and it would seem that they do not tend to decrease. This does not mean of course, that the theory is untenable, but there seems to be a growing tendency to exaggerate its claims to unqualified acceptance.

At least Srivastra has shown that the electronic theory of matter is not without an alternative; and this alternative, whatever difficulties it may present, certainly breaks new ground.

It is supposed that aether is atomic and not continuous and the difficulty, therefore, becomes an ultimate question; since it must be allowed that if this could be established, the cause of all phenomena, whether of matter or of force, must be sought in aether—the cause of causes; so that it appears that there is not one hypothesis, chemical or physical, that will remain unaffected.

In the domain of physics, this statement will more in particular apply; since without the original conception of aether—that of a continuous medium—part of the modern superstructure of physical science tumbles incontinently to the ground. It is because of this that definition must ultimately be applied in other directions that that of the structure of atoms; for, until now matter has been matter, and aether has been aether; and the assertion that aether is matter will, without careful definition, lead to that very confusion which the new hypothesis has been designed to avoid. Further criticism is undesirable, for it is partial to criticise in general terms a theory which has a particular application, and which may, when fully developed, be found applicable to all cases that may fall within its scope.

It is supposed that "matter is aether condensed"; and that "electricity is aether in motion." This is excellent, for it maintains that matter and force, despite their common origin, differ; and a fundamental distinction is therefore recognised that it seems desirable, at present, to preserve. It cannot be denied that "the aggregate of fixed electrons" of the electronic hypothesis is unconvincing, and it introduces an element that borders upon the inconceivable.

Srivastra claims that the particles of aether in motion constitute the negative electrons, but he denies the existence of the positive electrons. Even a superficial knowledge of the electronic theory of matter suffices to make some of its difficulties manifest; but the extracts from Prof. Berthond's paper seem to make the case for the positive electron very weak indeed, since it is maintained that "an electron appears as a corpuscle of electricity, devoid of any basis of matter; in the ordinary sense of the word it is at one and the same time the elementary particle of negative electricity, and an elementary particle of matter." Some such conclusion as this is certainly inevitable, but it involves a verbal contradiction, at least; and one so preposterous as to make the statement manifestly absurd.

It has been claimed for the theory of electrons that it has but amplified Franklin's hypothesis, but it must not be forgotten that the latter preserves a more definite distinction between the two kinds of electricty; or rather there is but one "positive fluid" and the "matter". The positive together with some negative electrons have been defined as matter, and in case of hydrogen, it would seem that one positive electron constitutes the nucleus; the resulting confusion is inevitable.

Srivastra seems to agree more nearly with Franklin; but the latter's positive "fluid" has become the negative electron; a necessary inversion which agrees with the electronic hypothesis. There seems to be some verbal confusion, however, in the manner that in the first place it is said that: "Electricity is aether in motion"; and later that "Negative electricity is produced by the motion of indefinitely small aether particles." This is open to more interpretations than one; and it might be construed to mean the very opposite of that which Srivastra desires to maintain. But that aethereal particles in motion are particles of electricity, *i.e.,* negative electrons, is doubtless meant.

The assumption that the condensed nucleus, by rotation about its own axis in one direction, generates positive electricty, and that the negative particles are in motion around the nucleus, but in the opposite direction, is convincing and satisfactory.

The real difficulty of the new theory lies in the fact that it may be difficult to restrain; in fine, aether has been made an element, and therefore, will not subordinate itself to its original function; while on the other hand, since its atomic weight is supposed to be zero, it will not subordinate itself to the laws of the other elements; and for such an element as this, insubordinate seems scarcely too strong a term. These difficulties are not necessarily insurmountable, but a more extensive survey is required; and it is hoped that before long, this matter will be again before us, for the question is interesting, and deserves, therefore, a detailed discussion.

*CHEMICAL NEWS, cxii., No. 3172.

NOTES ON THE ELECTROLYTIC REDUCTION OF GLUCOSE.*

By ALEXANDER FINDLAY and VERNON HARCOURT WILLIAMS.

THE possibility of reducing glucose electrolytically has attracted some attention in recent years, but the results obtained are somewhat conflicting Thus O'Brien Gunn [D.R.P. 140318 (1900)], states that glucose dissolved in sulphuric acid of 1-3 per cent concentration, can be reduced electrolytically using graphite electrodes and a cell with a diaphragm, the current density at the cathode being 0·15 amp. per square decimetre. A yield of manitol (?) amounting to 98 per cent of the theoretical is claimed to have been obtained.

*A Paper read before The Faraday Society, Tuesday, March 22, 192

W. Löb (*Biochem. Zeitschr.*, 1909, xvii., 132; xxi., 102; *Zeitschr. Elektrochem.*, 1910, xvi., 1) on the other hand, failed to obtain this satisfactory result, and was led to conclude that both the anodic and cathodic electrolysis of glucose leads to an equilibrium between glucose, a pentose, formaldehyde, and lower carbohydrates, the cathodic reduction causing the equilibrium to shift in favour of the production of the lower compounds.

As the reduction of glucose to the corresponding hexahydric alcohol is in itself a process of importance, it seemed worth while to investigate the electrolytic process more fully, and, more especially, to study the effect on the reduction of variation of the temperature, current density, and current concentration. Although, as the result of our investigation, negative results, as regards the production of hexahydric alcohol, have been obtained, we desire to communicate some notes on our work which may prove of value in connection with this problem.

The method and apparatus employed were essentially those used by Tafel (*Zeitschr. Physikal. Chem.*, 1900, xxxiv., 187), in his studies on electrolytic reduction. A closed cell was employed as cathode chamber, and the volume of hydrogen evolved during electrolysis was compared with that evolved from a hydrogen voltameter placed in series with the electrolytic cell. The difference in the volume of hydrogen evolved in the two cells represents the amount of hydrogen used up in the reduction.

The glucose used was "extra pure" glucose supplied by British Drug Houses, Ltd. Examined polarimetrically it gave a rotation corresponding with a purity of 99·87 per cent.

In most of the experiments lead electrodes were employed, and as Tafel has shown that the presence of metal impurities has a very unfavourable influence on the cathodic reduction, care was taken to ensure the purity of the lead electrodes employed. The purity of the lead was tested by analysis of the surface layers and the results of analysis were also confirmed by a repetition of Tafel's experiments on the reduction of caffein. This control served also to show that our method of working was satisfactory.

In the first series of experiments, carried out at the ordinary temperature, 14° to 17°, the current density employed was 0·16 amp. per 100 square cm., and the solution contained 1, 3, and 10 per cent. of glucose in 3 per cent. sulphuric acid. In all cases the rate of absorption of hydrogen fell off rapidly, practically to zero, and the total amount absorbed corresponded with no more than about a 2 per cent. reduction of glucose (see Table I.). In the following table, *t* is the total time in minutes from the commencement of the experiment; T, the time in minutes from the commencement of the experiment to the middle of each period during which successive readings of the burette were made; *e*, the volume in cc. of gas evolved in the electrolytic cell; *v*, the volume in cc. of gas evolved in the voltameter; E, the rate of evolution of gas in the electrolytic cell in cc. per minute; V, the rate of evolution of gas in the voltameter; R, the rate of absorption of gas in cc. per minute.

Table I.

Cathode liquid: 1 per cent, solution of glucose in 3 per cent sulphuric acid. Current density: 0·16 amperes per 100 square cm.

t.	T.	*e*.	*v*.	E.	V.	R.
0	2	0	0	0·125	0·300	0·175
4	6	0·5	1·2	0·187	0·262	0·075
8	10	1·25	2·25	0·212	0·312	0·100
12	14	2·1	3 5	0·250	0·300	0·50
16	18	3·1	4·7	0·262	0·287	0·025
20	22	4·15	5·85	0·250	0 287	0 037
24	26	5·15	7·0	0 262	0·300	0 038
28	33	6·2	8·2	0·270	0·285	0·015
38	45	8·9	11·05	0·271	0·285	0·014
52	57	12·7	15 05	0·280	0·285	0·005
62	67	15·5	17·9	0·275	0·290	0·015
72		18·25	20·8			

The total volume of hydrogen absorbed in the above experiment over the period of 72 minutes was only 1·42 cc. at N.T.P.

Similar results were obtained on commencing the electrolysis with a peroxidised lead cathode, and also when the sulphuric acid was replaced by sodium bisulphate as electrolyte.

Influence of Temperature.—On carrying out the electrolysis at a temperature of about 44°, no better results were obtained. The influence of temperature was found to be practically inappreciable; if anything, the hydrogen absorption was diminished.

Graphite Electrodes.—On using electrodes of gas carbon or of Acheson graphite the results were similar to those obtained with a lead electrode.

Current Density and Current Concentration.—In general, reduction of the cathode current density is accompanied by a slight increase in the efficiency of electrolytic reduction, but although we carried out an experiment with a current density somewhat lower than that previously employed (0·102 instead of 0·16 amp./sq. dcm.), no appreciable improvement was observed. It has, however, been shown by Tafel (*loc. cit.*), that current concentration (current per unit volume of solution), has a greater influence than current density. Experiments were therefore carried out in which the current concentration was varied between the limits of 0·04 and 0·444 amps. per 100 cc. The results obtained showed that with increase of current concentration, the absorption of hydrogen also increases but, as in previous experiments, falls off rapidly with time.

During the progress of these experiments it was observed that the cathode solution, after electrolysis, possessed a sharp aldehydic odour, and the cathode was found to be coated with a film of slimy appearance. This film was soluble in alcohol. As it was thought that the production of this film might be the cause of the rapid falling off of the volume of hydrogen absorbed by the depolariser, experiments were carried out in which the same solution was subjected to repeated electrolysis, the cathode, after each run, being treated with boiling alcohol to remove the film produced. After each treatment of the cathode it was found that a further absorption of hydrogen took place,

but that this absorption again rapidly fell off to zero. Using a current concentration of 0·444 amps. per 100 cc., and a cathode solution of 20 per cent glucose in 5 per cent sulphuric acid, the following successive absorptions of hydrogen were realised: 28·5, 8·1, 32·2, 52·8, 30·2, 24·1, and 23·5 cc. The total absorption amounted therefore to 199·4 cc., or 40·1 per cent of the theoretical amount. During these experiments, which extended over several hours, a considerable loss of glucose took place by diffusion from the cathode cell. In the most favourable case, where the highest current was employed, the loss amounted to nearly 30 per cent; where lower currents were employed and the duration of the electrolysis was therefore greater, the loss by diffusion was of course also greater. Attempts to diminish diffusion by use of a membrane of copper ferrocyanide deposited in the wall of the porous cathode cell, were not successful.

Since the foregoing experiments seemed to indicate that a considerable proportion of the glucose had been reduced, an attempt was made to isolate the supposed product of reduction, the hexahydrate alcohol. The solution was neutralised with chalk to remove sulphuric acid, and was then evaporated on the water bath. The syrupy liquid was dissolved in concentrated hydrochloric acid, and the acid solution shaken with benzaldehyde and allowed to stand for several days. By this means, mannitol or sorbitol, if present, can be precipitated as a condensation product with benzaldehyde (Meunier, *Compt. Rend.*, 1888, cvii., 910). No such compound, however, was obtained, and we are therefore driven to conclude that no appreciable amount of hexahydric alcohol was produced in our electrolytic experiments.

On examining the alcoholic washings from the cathode, a lead salt was isolated which, on analysis, was found to be lead formate. Formic acid was also found in the cathode solution after electrolysis. The production of this acid in the electrolytic reduction of glucose is mentioned by Löb (*Zeitschr. Elektrochem.*, 1910, xvi., 1), who states that glucose decomposes into formic acid and a pentose. The presence of pentose in the solution we detected by the furfuraldehyde test.

Further evidence of the production of formic acid was obtained from an analysis of the gas evolved at the cathode during electrolysis. This gas was found to be not pure hydrogen but to contain about 4 per cent of carbon monoxide, produced, presumably, by a decomposition of formic acid. The percentage of carbon monoxide varied somewhat during electrolysis, being greater during the earlier than during the later stages of the electrolysis. Although the destructive reduction of glucose with production of formic acid and a pentose does not appear to take place to a very large extent, the formation of these compounds may play an important part in the process of electrolytic reduction if, as seems probable, it is the formic acid which leads to the formation of the film on the cathode with consequent diminution or prevention of further reduction.

As a result of our experiments, which are in harmony with the results obtained by Löb, we are forced to conclude that, contrary to the claims of O'Brien Gunn, no hexahydric alcohol is produced in the electrolytic reduction of glucose.

OVERGROWTHS ON DIAMOND.*

By J. R. SUTTON.

The Affinity between Diamond and Carbonate of Lime.

"FORMERLY the diamonds were picked out from the concentrates by means of the keen eyes of skilled natives, but the process has been vastly simplified . . . by the remarkable discovery made in 1897 by F. Kirsten of the De Beers Company, that of all the heavy constituents of the blue ground, diamond alone, with the exception of an occasional corundum and zircon, which are easily sorted out afterwards, adheres to grease more readily than to water. In this ingenious machine . . . the concentrates are washed over a series of galvanised-iron trays, which are covered with a thick coat of grease. The trays are slightly inclined downwards, and are kept by machinery in constant sideways motion backwards and forwards. So accurate is the working of this device that few diamonds succeed in getting beyond the first tray, and none progress as far as the third."

This account, which contains nearly all that is necessary by way of preface, is extracted from G. Herbert Smith's charming "Gem Stones," 1912, p. 148. Evidently the secret of the process, as Lawn has said, is surface tension. Common minerals can easily be wetted, whereas diamond cannot be; and because of the wetting the grease cannot touch the mineral surface, whereas it can touch the dry diamond.

According to G. F. Williams "only about one-third of 1 per cent of diamonds is lost by the first table, and these are recovered almost to a stone when the concentrates are passed over the second table" ("The Diamond Mines of South Africa," 1902, p. 380).

J. Stewart reports further that for the six months July to December, 1909, out of 1,211,552 carats of diamonds recovered at the De Beers Company's pulsator, all but 1,249 carats were caught on the first tables—an efficiency of 99·9 per cent.

But it is a curious fact that while diamonds of all kinds, including bort, from the blue ground adhere readily to the grease tables, those from the surface yellow ground are much less easily caught. Some years ago a parcel of diamonds from the Wesselton Mine yellow ground was handed to me for examination. Some concentrates from the yellow ground had been passed over the grease tables with the following result:—

	Carats caught.	Per cent.
First table	241	50·52
Second table	90	18·87
Third table, and final dry sorting of rejected concentrates	146	30·61
	477	100·00

That is to say, instead of a loss of between one-tenth and one-third per cent (the values quoted above), only about half of the diamonds were caught on the first table—a result scarcely better than an electrostatic separator would give. Clearly it was lucky that the grease tables were

* From the Transactions of the Royal Society of South Africa.

not thought of in the early days of Kimberley, when nothing but yelow ground was being worked for, had they been tried then, that excellent invention would probably have passed stillborn into oblivion.

In the matter of the anomalous behaviour of the yellow-ground diamonds the problem to be solved was unique, inasmuch as there was no outside analogy for a guide. To begin with, there was nothing to show whether the surface of yellow-ground diamond was essentially different from that of blue-ground diamond, or whether the anomaly arose from some disturbing factor in the matrix. As to the former alternative, there was a prevalent belief that the surfaces of diamonds found in the early days of Kimberley were on the whole more brilliant than those obtained later, in the deep workings. As to the latter alternative, it appears that the soapy-feeling substance lining the blue-ground matrix of diamond has not quite the same constitution as adjacent blue-ground has. This point will be referred to again.

The first step in the attempt to solve the problem was made by screening the diamonds caught on the three different tables into series of sizes. From the results it was ascertained that, generally speaking, the larger diamonds tended to adhere to the grease on the first table better than the smaller ones did, those caught on the third table not often exceeding a quarter of a carat each. There was, moreover, a marked difference in the behaviour of the smaller diamonds with respect to the tables, for while those caught on the third table, or dry sorted afterwards, were largely of good shape with no specially great proportion of cleavages and splinters, those caught on the first table were mostly irregular or broken pieces. Hence it seems that a still larger quantity would have been lost by the first table if the normally great percentage of Wesselton cleavage were less. Two possibilities were thus suggested :—

(1) The larger diamonds stick better than the smaller ones do because their weights being great relatively to their surfaces they travel more slowly in a given current of water, and so can sink mechanically more heavily into the grease. Here it may be noted that pieces of iron and heavy minerals sink into the grease not because of any attribute of surface tension, but because the current of water flowing over the tables is insufficient to overcome gravitation.

(2) Apart from that, some peculiarity of surface seemed involved whereby fractured faces were more adhesive than natural faces. On the other hand the sharp edges of the fractured faces can plunge mechanically into the grease with more facility than natural edges can.

Under magnification, however, no characteristic difference could be detected either between the surfaces of the diamonds taken from the different tables, or between the surfaces of the non-adhesive yellow-ground diamonds and the surfaces of ordinary adhesive blue-ground diamonds. Some specific gravity tests, also, reveal no differences worth mention.

Since only a few diamonds from the blue ground are normally lost by the first grease tables, it remained to examine typical specimens of blue and of yellow ground in order to determine whether any accountable peculiarities exist in the respective matrices which might be communicated to a diamond surface. Competent geologists are pretty unanimous that the yellow ground, which may go down even to 70ft., is simply blue ground in a weathered condition, and contains the same minerals in due proportion" (W. H. Penning, "Gold and Diamonds," 1901, p. 4). But unanimity in the case of the diamond is never evidence, and, for the most part, judging by the strong family likeness of the various accounts, each high expert quotes without question from some higher expert. At any rate, some samples of blue ground, yellow ground, and so-called "limestone" from the original overburden, were obtained for testing purposes from the Wesselton mining area. So far as could be seen the samples of yellow ground were typical and clean. The blue ground had other matter mixed up with it, which had probably been scraped up from the depositing floors by the shovel. It could only be guessed whether the "limestone" was an average sample of its kind. It was a spongy-looking stuff of rather low specific gravity (?altered blue ground, or dolomitic), and to casual inspection carried particles of yellow ground. Portions of each of the three kinds of ground were crushed, gently dried, weighed, treated with dilute acid, evaporated to dryness, and again weighed, with the following result :—

	Weight before treatment.	Weight after treatment.	Loss Per cent.
Blue	10·000	9·225	7·75
Yellow	10·000	8·650	13·50
"Limestone" ...	10·000	9·975	0·25

In the acid the blue ground effervesced strongly, the yellow ground violently, the limestone scarcely at all. A sample of hard blue from De Beers Mine, tested at the same time, gave scarcely any effervescence, while some lumps of hard and soft limestone from Kenilworth effervesced violently, leaving no great proportion of insoluble residue, so that the effervescence of the blue ground may have arisen, at any rate in part, from an admixture of a foreign carbonate. Moreover, the substance (alluded to above) lining the matrices of sundry blue-ground diamonds effervesced very little.

These rough tests seemed to supply a clue worth following towards a solution of the problem. There is more carbonate of lime in yellow ground than there is in blue ground, and the question is: Will it, when it is plentiful enough, spread itself on a diamond surface in a crust capable of being wetted? Numerous experiments were accordingly made in the hope that premised feasible natural processes might to some extent be imitated in forming such a crust. Pastes were made of the blue ground, the yellow ground and the limestone, with hot and with cold water, in which small diamonds that had adhered normally to the first grease table were enclosed for some days. Sometimes these pastes were kept wet throughout, sometimes they were dried in gentle heat, and sometimes left to dry of themselves. Finally the enclosed diamonds were taken out and run over the grease tables at the pulsator. The results were only so far encouraging that neither the diamonds from the yellow paste nor those from the limestone paste showed any particularly marked inclination to stick to the grease. But on the other hand, curiously enough, neither did the diamonds from the blue paste. Thus although all

were originally normal first table captures, the act of putting them into the different pastes had for the most part destroyed their adhesive property.

Of course, only a soft and easily removable crust, at the best, can be deposited on diamonds by enclosing them for short periods in pastes of this kind. One effort was made to deposit a harder crust on four first table diamonds of about six carats each by placing them in four separate vessels with some blue, yellow, and lime ground respectively, well stirred with plenty of water, and leaving the water to evaporate slowly. This is a lengthy process, and was only partially successful. Scarcely any blue ground appeared to have attached itself to the diamond surface, though the lime and yellow were deposited in patches with some freedom. Upon roughly testing these diamonds for surface tension in water, it was found that those from the lime and yellow grounds gave much higher values per unit area of surface than those from the blue ground did, albeit a single test of this kind cannot be regarded as of much consequence. These same diamonds were afterwards passed over the grease tables: three adhered, and one, which had a fair coating of lime, rolled away.

The experiments were repeated with three good samples of virgin blue, yellow, and real limestone crust, obtained from the Kamfersdam Mine. In acid the blue gave no effervescence to speak of, while the yellow effervesced strongly, losing 20 per cent of its weight, and the lime crust violently, losing fully 60 per cent. Pastes were now made as before of the virgin blue and of the lime crust in equal quantities, and ten first table diamonds, weighing on an average about a carat a-piece, were placed in each paste. The two lots of diamonds were chosen so as to be nearly alike as possible. After the pastes had become quite dry they were broken, the diamonds were carefully extracted, soaked in water, and passed over the grease tables. Every diamond from the limestone paste rolled off as fast as the water could carry it; whereas nearly all the diamonds from the blue were caught.

Lastly, some third table and dry sorted diamonds, *i.e.*, diamonds which originally were not easily caught, or even not caught at all, by the grease, adhered quite well after having been cleaned in acid.

(To be continued.)

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

March 10, 1921.

PROF. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read :—

"*Electro-crystalline Properties as conditioned by Atomic Lattices.*" By SIR JOSEPH LARMOR, F.R.S.

The view, confirmed on grounds of ultra-optical analysis by Bragg, that the crystal lattice is usually composed of atoms, not concentrated into chemical molecules, is considered in relation to their ionic charges. Compensating surface charges on certain types of faces of a crystal are required; and inference is drawn with regard to the texture of crystal faces. The alternative view that a bipolar molecule is the crystal-unit would seem to encounter difficulties also as regards pyro-electric effects. Dielectric excitation can be represented as *relative* displacement of the positive and negative component lattices, under the influence of an electric field. If the compound lattice has spiral features, so that the relative shifts of its various components with positive and negative charges are of screw type, chiral optical quality will be involved; a coarse numerical estimate indicates that in quartz and active liquids the twisting relative displacement of the ionic configurations is comparable in amount with their relative elongation, as would be natural in the spiral lattice. The chiral quality may reside wholly in the crystalline structure, disappearing on fusion or solution; or else the process of dielectric displacements of the positive and negative groups of ions in the crystal-unit may be also itself chiral. In either case induced static polarity could not be chiral as regards waves so long as those of light; but this process of screw displacement is operative kinetically in the optical rotation, by involving a magnetic moment of changing ionic twist induced by the alternating electric field of the radiation. The octo-polar pyroelectric quality in the faces of crystals of cubic type, explored originally by Haüy, need not now have to be referred to strains arising from irregular cooling, but a face containing both types of ions equally should now acquire no true pyro-electric charge. Double refraction induced by strain must be ascribed to bending of ionic lattice structures, as molecules could hardly bend, or in glass to fragments of such structure.

"*A Generalisation of Weyl's Theory of the Electro-Magnetic and Gravitational Fields.* By PROF. A. S. EDDINGTON, F.R.S.

From the notion of "parallel displacement" used by Weyl in his theory, it is shown that a tensor $*B^{\rho}_{\mu\nu\sigma}$ exists giving a measure of the world-structure at each point. The contracted tensor $*G_{\mu\nu}$, formed by setting $\rho=\sigma$, breaks up into two parts, (1) a symmetrical part which is the gravitational potential $g_{\mu\nu}$ of Einstein's theory, and (2) an antisymmetrical part $F_{\mu\nu}$ (proved to be the curl of a vector) which is identified with the electro-magnetic force. The theory explains how, notwithstanding the non-integrability of length in Weyl's geometry, there is, nevetheless, a natural gauge; and Einstein's *interval* is an absolute invariant independent of gauge, and directly comparable with other intervals at a distance, as he assumed it to be. The law of gravitation for empty space in the form finally adopted by Einstein, viz., $G_{\mu\nu}=\lambda g_{\mu\tau}$, follows at once on this theory. All the other recognised field-laws are found by identifying the physical measures with geometrical tensors which satisfy these laws identically. None of these impose any constraint on the possible varieties of world-structure; and there is no reason to introduce a physical principle of stationary action, at least so long as we do not deal with problems of electron structure. Explicit expressions for $*B^{\rho}_{\mu\nu\sigma}$ and $*G_{\mu\nu}$ are found in

terms of Einstein's gravitational tensors and a tensor $K_{\mu\nu,0}$ which represents electric and electronic forces. Weyl's theory corresponds to the particular case when $K_{\mu\nu,0}$ is of the form $g_{\mu\nu}q_0$.

"Spectrophotometry in the Visible and Ultra-violet Spectrum." By PROF. T. R. MERTON, F.R.S.

The application of the neutral wedge to spectrophotometric measurements is at present limited to the visible spectrum and the less refrangible parts of the ultra-violet spectrum. A description is given of a method by which this limitation is removed. The method involves the "crossing" of the prismatic spectrum with a diffraction spectrum, the relative intensities of the different orders in the diffraction spectrum having been experimentally determined. The method of preparing and calibrating gratings for this purpose is described. The method is applicable to the determination of the relative intensities of lines in discontinuous spectra, but is specially adapted to the study of continuous spectra, absorption spectra, and the study of broadened lines. It is suggested that the method may have a special application in celestial spectroscopy.

"Researches upon Brown Coals and Lignites. Part I.—Heat Treatment at Temperatures below 400° C. as a Possible Method for Enhancing their Fuel Values." By PROF. W. A. BONE, F.R.S.

A classification of lignites is made according to their external appearance:—

(a) Woody or fibrous brown coals.
(b) Amorphous or earthy brown coals.
(c) Common or brown lignites.
(d) Black lignites.

Lignites have a moisture content varying between 10 and 50 per cent; on air-drying they usually disintegrate or crumble to powder. They are devoid of any cooking properties, and in the "dry ashless" state usually contain less than 70 per cent. of carbon and more than 20 per cent of oxygen.

Experiments were conducted on the various types of lignites — from Australia (Victoria), Burma, Canada (Saskatchewan), and Italy (Tuscany and Umbria). The method was to heat in a special form of apparatus that allowed accurate measurement of temperature and amounts of liquid and gaseous products.

On heating the lignite chemical change takes place, beginning at a low temperature of about 130° C., and progressing to a temperature at which no condensable hydrocarbons were eliminated from the fuel, termed the "practicable upgrading limit." During this period of heating, steam and carbon dioxide, with a small amount of carbonic oxide and a negligible amount of hydrocarbons, were eliminated. The gaseous products after condensation of the steam usually consisted of about 95 per cent of the two oxides of carbon.

This treatment showed a loss of between 8 and 15 per cent of its original weight at the expense of the oxygen content, which was diminished by between one-quarter and one-third of its original value. Practically the whole of the potential energy of the lignite is concentrated in the residue obtained by this "up-grading" treatment; hence it has greater calorific intensity than the original.

"A Superior Limit to the Age of the Earth's Crust." By PROF. H. N. RUSSELL.

The method of determining the age of a mineral from the ratio of lead to uranium in its composition may be extended to the earth's crust as a whole. On the usual assumption, and accepting a radium content of $2\cdot5\times10^{-12}$ (Joly), corresponding to a uranium content of 7×10^{-6}, and a content of lead of 22×10^{-6} (F. W. Clarke), it follows that the age of the crust does not exceed 11×10^{9} years, which is reduced to 8×10^{9} years, if allowance is made for thorium.

The effects of uncertainty in the assumptions are considered, and it is concluded that the earth's crust has probably existed as such for between two and eight thousand millions of years.

"Reversal of Asymmetry in the Plutei of Echinus miliaris." By H. OHSHIMA.

In the normal Echinoderm larva the hydrocœle and its associated structures, which together give rise to the water-vascular system, develop on the left side of the larval body. Rarely the reversal of this asymmetry occurs, and of this a very few instances have hitherto been recorded.

This abnormality was found in more than 10 per cent of the artificially-reared larvæ of *Echinus miliaris*. It may be a result of (1) change of polarity in the egg, or (2) twin-formation, or, most probably, (3) "compensatory hypertypy," owing to the arrest in development and subsequent atrophy of the normal left hydrocœle. The right anterior cœlom is known to have the latent potentialities of producing a hydrocœle. The potentialities can probably be activated by the stimulus, due to the arrest in development of the left hydrocœle. The arrest is probably associated with the obliteration of the pore-canal, through which the hydrocœle has been communicating with the exterior.

The occurrence in much lower percentage of the double-hydrocœle larvæ and those devoid of the hydrocœle within the same culture jars can also be explained in connection with the above-mentioned third possibility. If the left hydrocœle regains its communication with the exterior, either by the reappearance of the pore-canal or by the fusion of the right and left anterior cœloms, it will continue to develop further hand in hand with the abnormally appeared right hydrocœle, so as to give rise to the double-hydrocœle larva. If the right hydrocœle fails to appear while the left hydrocœle is still deprived of its communication with the exterior, and thereby ultimately atrophies, a larva devoid of hydrocœle will result.

THE SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS.

February 2, 1921.

ANNUAL ADDRESS OF THE PRESIDENT, MR. ALFRED SMETHAM.

IT has been customary in the past for the President of the Society at the Annual General Meeting to bring under survey the activities of the members

and the work and progress of the Society in the official year that sees its close at the Annual Meeting; and it thus falls to my lot to-day to review the proceedings of the past year. Following as I do in the footsteps of a long array of brilliant chemists and able administrators, I feel that the task of doing adequate justice to the subject is no light one, and I would that I could relegate the duty now imposed upon me to someone better fitted for the post; but since the address must in the main be a *résumé* of the work of others rather than an exposition of one's own views, I have greater confidence than I should otherwise feel in imposing my remarks upon you.

During the year ending December 31, 1920, the total number of members, including 11 honorary members, has increased from 448 to 454. New members elected number 26, while we have lost 8 members by death, 8 members have resigned for various reasons, while three members have been removed for non-payment of their subscriptions.

The names of the deceased members whom we mourn are: William Beaverly Cowie, Walter William Fisher, James Wright Gatehouse, Alfred Howard, John Ruffle, Robert Tervet, Elwyn Waller (of New Jersey, U.S.A.), and Samuel Archibald Vasey.

Obituary notices have appeared in the pages of the *Analyst* of Walter William Fisher and James Wright Gatehouse.

Walter William Fisher was one of the oldest members of the Society of Public Analysts, and acted as its President in 1889 and 1890. He was Public Analyst for the counties of Oxford, Berks, and Bucks, as well as for the City of Oxford, which posts he held for nearly 40 years, and to within a week of his death carried out actively the duties appertaining to the posts. We deplore his death, and the many members of the Society who knew him have to lament the loss of a staunch friend.

James Wright Gatehouse died on October 16, 1920, at Bath, at the age of 79. In 1877 he was appointed Public Analyst for the City of Bath, and, eleven years later, Public Analyst for Wiltshire. In addition to his duties as Public Analyst, he carried on a private practice, and did much good work in various investigations.

By the death of John Ruffle I have lost a friend of over 40 years' standing. Although of a gentle and retiring nature, he was a man of many parts, and did much useful work. He will be best remembered, perhaps, as the originator of the Ruffle method for the estimation of nitrates by the combustion process.

During the session 23 papers were read, while 32 papers and 8 "notes" were published in the *Analyst.*

During the year 1920, the following papers appeared in the pages of the *Analyst*:—

"A New Method for Detecting Adulteration in Butter and for Estimating Fats of the Coconut Group." By George Van B. Gilmour

"A New Process for the Estimation of Arsenic, with Notes on the Chemistry of the Marsh-Berzelius Process." By B. S. Evans.

"The Estimation of Mercury." By H. B.

"An Investigation into the Composition of the Unsaturated Hydrocarbons present in Coal Gas." By F. S. Sinnatt and L. Slater.

"The Estimation of the Available Oxygen in Sodium Perborate and in Perborate Soap Powders." By H. Trickett.

"The Differentiation between Poor and Adulterated Milk." By T. R. Hodgson.

"Machine for Washing Precipitates." By Eric Sinkinson.

"The Detection of Finger-Prints on Documents." By C. Ainsworth Mitchell.

"Photomicrography with Simple Apparatus." By Thomas J. Ward.

"Note on the Solubilities of Theobromine." By Raymond V. Wadsworth.

"A New Method for the Estimation of Methyl Alcohol." By S. B. Schryver and Cyril Christian Wood.

"Note on Opium Poisoning." By E. H. Hankin and D. Chatterji.

"An Examination of Certain Milk Records." By G. W. Monier Williams.

"An Improved Slide Rule for Dairy Calculations." By H. Droop Richmond.

"The Examination of Chinese Crude Camphor." By E. R. Dovey.

"Estimation of the Age of Ink in Writing." By C. Ainsworth Mitchell.

"A Rapid Volumetric Method for the Estimation of Iron, Applicable in the Presence of Hydrochloric Acid, Phosphorus, Oxy-acids, and Organic Matter." By H. Droop Richmond and Edith M. Ison.

"The Estimation of Nitroglycerin." By H. Droop Richmond.

"The Effect of Pressure upon the Polenske and Reichert-Meissl Values." By Vincent H. Kirkham.

"The Composition of Milk in British East Africa." By Vincent H. Kirkham and A. C. Barnes.

"Note on the Refractive Indices of Mixtures of Isopropyl Alcohol and Acetone." By Dorothy Muriel Palmer.

"The Estimation of Codeine." By H. E. Annett and Haridas Sen.

"The Influence of the Free Fatty-Acid Content in the Valuation of Chinese Wood Oil by the Browne Polymerisation Test." By Philip E. Jameson.

"Apparatus for Evolution Methods of Analysis." By E. R. Dovey.

"An Improved Form of U-Tube." By E. R. Dovey.

"A Study of the Determination of Potassium as the Perchlorate, and the Separation from Sodium, etc." By R. Leitch Morris.

"Notes on Rubber Analysis." By A. R. Pearson.

"An Improvement in the Haldane General Air Analysis Apparatus." By Robert C. Frederick.

"The Gravimetric Estimation of Bismuth as Phosphate and its Application in Ore Analysis." By W. R. Schoeller and E. F. Waterhouse.

"The Position of Analytical Chemistry in France." By L. Cofman.

Statutory Standard for Ghee." By T. K. Ghose.

In addition to the papers published, the "Notes" on analytical methods and other matters have proved exceedingly interesting and useful, and I welcome this comparatively new departure as a

During the year thirty-two books have been reviewed in the pages of the *Analyst*. In my opinion these Reviews have been wholly admirable. They have been fearlessly and faithfully done by experts in the subjects reviewed whose judgment is reliable. They have brought to my notice some books of sterling value, and in other cases have saved my pockets from being depleted of cash and my bookshelves from being overloaded with trash.

Before leaving the subject of the publications in the *Analyst*, I cannot refrain from mentioning the loss which the Society has sustained by the resignation of Mr. Julian L. Baker as Editor of the *Analyst* to assume the Editorship of the *Journal of the Institute of Brewing*. Mr. Baker has been Editor of the *Analyst* for 13 years, during the whole of which time the Journal has been admirably conducted, and each succeeding year, thanks to his assiduous attention and genius, has seen, I think it will be generally admitted, an improvement on the previous ones. Bowing to the inevitable, we very reluctantly relinquish him, knowing that what is our loss is his and others' gain.

Fortunately, we have been able to secure in Mr. Baker's stead a new Editor, Mr. C. A. Mitchell, who is well-known to us by his scientific abilities, his literary merits, and his devotion to the Society and its publication. Mr. Mitchell as an author has a high reputation, and he has been an Abstractor for the *Analyst* for a long time. To him we may look with confidence to maintain the high standard and traditions of our Journal.

It was with much satisfaction that we welcomed back our Hon. Treasurer, Mr. E. Hinks, who has returned safe and sound to resume his duties. At the same time I ought to voice the thanks of the Society to Mr. E. W. Voelcker as Acting Treasurer during Mr. Hinks' absence.

Before leaving this part of my subject, I should like to take this opportunity of congratulating one of our past Presidents (Mr. A. Chaston Chapman) on his election as a Fellow of the Royal Society.

We have to regret the prospective loss, by absence abroad—we hope for a comparatively short period only—of our old and faithful friend, Otto Hehner. Mr. Hehner is too well known to all of us to render it necessary for me to recall to your minds all the posts he has held and all the work he has done to further the interests of the Society and to advance the cause of analytical chemistry.

Of the many questions which have come before your Council for consideration, one has been a motion to ascertain whether the present somewhat cumbrous title could not be modified in such a way as to include all the present members, while at the same time the prestige of nearly 50 years' strenuous work and endeavour under the old title could be preserved. Legal advice has been taken, and I understand that there is no legal difficulty in altering the name of the Society, and at the same time of preserving the privileges which we at present enjoy. It is not an easy matter to select a title which will be at once descriptive, inclusive, and euphonic; but there should be no insuperable difficulty in finding a solution.

The original title of the Society of Public Analysts has become so widely known and respected that in many ways it seems a pity to hide its identity under a new title; but as the term public analyst is limited by Act of Parliament to those analysts appointed under the Food and Drugs Act—and cannot, therefore, be appropriated by practising analysts generally—there seems no alternative but to change the name or continue as at present. Doubtless some happy solution of the problem will be evolved, but of the suggestions hitherto made none seem quite to meet my æsthetic taste. There is a crispness about our original title which seems to arrest the attention at once.

The fact that the proportion of analysts other than public analysts has been steadily increasing renders the alteration in the title, if it is to be descriptive of the objects of the Society, the more necessary, and as the number of public analysts is practically stationary, while the analysts engaged in general practice and in connection with trade and manufactures are steadily increasing, and, with returning trade and prosperity, are bound to increase rapidly, it seems to me that if the alteration in title is necessary or desirable, the present is an opportune time to make it.

I have said that the proportion of analysts other than public analysts is in the future likely to increase at a rapid rate, and I am basing the statement on a careful observation of commercial and manufacturing conditions for a period of over 40 years. When I went into practice my work consisted for the most part of analyses to assist in the control of manufacturing processes, or to help purchasers to make a selection of produce sold practically on a flat rate; and very few of the analyses were sent under contracts, the price to be decided by the contents of the valuable constituent or constituents, as the case might be.

As the years went on and rule of thumb in manufactures was replaced by more scientific control, purchasers insisted on safeguards, especially when buying forward, and by gradual evolution in nearly every branch of industry. Safeguards in contracts are inserted, and in many instances these safeguards take the form of restrictions based upon analytical control.

Concurrently with the altered conditions in manufacturing methods, and the greater demand for more definite specifications with regard to quality, especially when the goods in question have been bought to arrive, the demand has arisen for increasing the safeguards against any inferiority in the produce which may be tendered in fulfilment of a contract. This desire on the part of the more progressive merchants and manufacturers has brought into existence a considerable number of combinations of diverse interests, who, forming themselves into associations representing their respective trades or businesses, have generally controlled the transactions, especially in the case of our overseas trade. Each year sees the framing of innumerable new contract forms, and the modification of old ones, and with the increase in the stringency of the demands on the part of buyers there has been necessarily an increase in the volumes of work falling to the lot of analysts in general. And if I read the signs of the time aright it seems to me that the tide having begun to flow in this direction it will continue to do so until a high-water mark has been reached and practically the whole of our commerce brought

under scientific control. The employment of men of exceptional talent by companies and associations for the pursuit of pure research, in contradistinction to the control of manufacturing processes or business transactions, is evidence sufficient to indicate that our leaders of commerce and industry are rapidly realising, thanks partly to work done by chemists and other scientists during the war, that research work is not only a necessary adjunct to a successful business enterprise, but it is at the same time a highly profitable investment.

And I am glad to see this tendency on the part of leading business men to call to their assistance the best brains of our profession, because it must inevitably have a leavening effect on the general mass of business men who, in the past, have regarded chemists, not as a necessary controlling influence in the factory or in business, but as an unavoidable adjunct to the business side of their concerns.

The admirable work done during the war by so many members of our profession, both at home and abroad, and the important part played by the investigations and work of our chemists in finally winning the war, has brought home to the nation at large the immense importance and possibilities of chemistry, not only in fostering the interests of our own industries, but in advancing the cause of civilisation the world over. That the ever-increasing developments of chemistry should have been so directed as to have caused such world-wide havoc is greatly to be deplored, and it is to be hoped that the effects produced and the lessons learned will have throughout the ages the effect of teaching future generations the folly of diverting our beloved science from the arts of peace to those of war.

But to revert to my theme. The formation of the numerous bodies and associations, which I have referred to, has increased the volume of analytical work largely, and to that extent it is a good thing for the profession generally, but as the effect, so far as the commercial side of our work is concerned, is to increase the number of analyses of a similar nature there is a tendency to render a good deal of our work tedious and to some extent monotonous. In the nature of things such a result is almost inevitable, as with greater proficiency and greater experience in any particular direction the confidence of one's clients in one's work is sure to grow and, snowball-like, the volume of work is sure to increase, and thus the routine of the laboratory is too apt to assume the functions of something approaching a factory rather than the purely investigational work which we usually associate with a scientific laboratory.

In this respect, however, we are not far removed from the specialists in medicine or surgery who, after along preliminary training, find themselves in the hey-day of their prosperity dealing with special cases day in and day out.

There is, of course, in addition to the purely routine side of a practice, a considerable amount of work of a highly technical and exceedingly interesting nature which breaks the monotony of life and gives a zest to one's daily occupations.

The point which I am aiming to make clear is that, although the tendency of the age is to make specialists of us all, care must be taken to found that specialisation upon a sound scientific basis, and to avoid drifting into mere machines in controlling a limited section of trade or industry. Up to the present the policy of the trade associations has been almost universally to entrust the analytical work to trained chemists who have won the confidence of the public; and I think it will be a bad day for the trades concerned and for our profession if, as has been proposed in some cases and adopted in others, analysts are appointed at fixed salaries, or inadequate fees, to undertake the work of the associations I have referred to.

The question of professional fees, and the remuneration of chemists in general, is a somewhat complicated one, and there does not seem to be any way in which one or the other can be standardised. With regard to the fees charged by practising analysts, I think it will be generally agreed that before the war the charges made, even by leading men, were in many directions quite inadequate. This was partly due to a keen competition amongst chemists for what little outside analytical work was required in the earlier days, when the analyses were required for private information or control purposes. In some cases the fees were cut by men who had been inadequately trained, but as often no very great degree of accuracy was required, and very little opportunity was afforded of checking the results, there was no elimination of the least capable, and the competition of these with the better-trained men kept fees at a low level. In this way in many branches of work fees became more or less fixed, and by a general understanding they had to be accepted, especially by the younger members of the profession. Once fixed for any particular analysis it was very difficult for the individual to raise the fees without the risk of losing the work altogether. Thus it happened, in my case at all events, that a very considerable part of my practice was carried on at very little profit to myself.

With the altered conditions brought about as the result of the war it became imperative that a revision of fees should be made, and even the most altruistic of us were compelled by the force of necessity to raise our fees. The Institute of Chemistry made inquiry into the matter, and in the February number of the *Journal and Proceedings of the Institute* for 1920, stated that, as the result of their investigations, "the Council are of opinion that Fellows and Associates are justified in making a corresponding increase in their fees for professional services." Although unable to recommend any definite rate of increase over pre-war rates, the Council of the Institute state that an increase of 50 per cent cannot be regarded as excessive, while some practitioners have doubled their fees. This practically is the attitude which I myself have taken, readjusting the fees according to the work involved, but it is a matter of doubt whether the increases made in the fees cover the extra costs involved under present conditions.

With regard to chemists employed in whole-time engagements, I am afraid that in many instances the increases in remuneration have not been commensurate with the enhanced value of their services and the extra cost of living; but it is to be hoped that with the efflux of time and the stabilisation of the exchanges, the burdens at present borne will gradually be removed, and adjustments made which will remedy the present hardships.

During the past year your Council has worked assiduously, and, under the able guidance of our Secretaries, has kept the business of the Society and the interests of its members constantly in review.

One Committee, consisting of Messrs. L. Archbutt, W. J. A. Butterfield, G. Nevill Huntley, and G. Rudd Thompson, appointed by the Council to consider the desirability of making provision for supplies of standard chemical substances, has transmitted to the Council of the Institute of Chemistry a Report, a summary of which appeared in the September number of the *Analyst*.

The Committee is satisfied that there is a demand for Analytical Control Standards, at present being chiefly met by private enterprise and by the importation of the U.S.A. Bureau of Standards Samples, and that the demand appears reasonable for checking and educational, rather than commercial purposes.

The Committee recommend that the Society of Public Analysts should take the initiative in forming a representative Analytical Standards Committee, and the Council of the Institute of Chemistry have concurred with that recommendation, and have nominated Mr. F. H. Carr, Dr. J. T. Dunn, Mr. Lewis Eynon, and Mr. F. W. Harbord to act as its representatives.

That standards such as have been prepared or proposed would prove a great service, especially for educational purposes, scarcely admits of a doubt, but when it is suggested that these standards should be analysed side by side with commercial samples submitted for analysis, and that the fact should be stated on the certificate, I am very clearly of opinion that such use would be detrimental to the profession, and damage its prestige. In most cases the materials for which standards would be prepared would be commercial products, the analyses of which are almost invariably placed in the hands of experts, who are past-masters in the particular branch of analysis. To make any such statement such as that suggested would be tantamount to an admission of incompetency.

And now, in conclusion, I have to express to our indefatigable and ever courteous Secretaries, Mr. P. A. Ellis Richards, and Mr. E. Richards Bolton, the deep debt of gratitude under which I have been placed by their many kindnesses and invaluable promptings, both with regard to procedure and policy, during the year now coming to an end.

BOOKS RECEIVED.

"A Dictionary of Applied Chemistry." By Sir Edward Thorpe, C.B., LL.D., F.R.S. Vol. 1. Revised and enlarged edition A. to Calcium. 752 Pages. London: Longmans Green & Co. Price 60s. net.

"An Introduction to Zoology for Medical Students." By C. H. O'Donoghue, D.Sc., F.Z.S. 501 Pages. London: G. Bell & Sons. Price 16s. net.

"Applied Colloid Chemistry: General Theory." By W. D. Bancroft. 345 Pages. London: McGraw-Hill Publishing Co. Price 18s. net.

"Creative Chemistry: Descriptive of Recent Achievements in the Chemical Industries." By Edward E. Hosson, M.S., Ph D. With many Illustrations. 311 Pages. London: London University Press, Ltd. Price 12s. 6d. net

"Volumetric Analysis for Students of Pharmaceutical and General Chemistry." By Charles H. Hampshire, B.Sc., F.I.C. Third Edition. London: J. & A. Churchill. Price 7s. 6d. net.

"Physical and Chemical Constants and Some Mathematical Functions." By G. U. C. Kaye and T. H. Laby. Fourth Edition. London: Longmans Green & Co. Price 14s. net.

"The Chemistry of Synthetic Drugs." By Percy May, D.Sc. (Lond.), F.I.C. Third Edition. 248 Pages. London: Longmans Green & Co. Price 12s. net.

NOTES.

Royal Institution.—On Tuesday next, April 5, at 3 o'clock, Prof. R. A. Sampson, Astronomer Royal for Scotland, delivers the first of two lectures at the Royal Institution on (1) "Present Position of the Nebular Hypothesis"; (2) "Measurement of Starlight." The Tyndall lectures will be delivered by Mr. C. T. R. Wilson on "Thunderstorms," beginning on Thursday, April 7; and on Saturday, April 9, Dr. H. H. Dale begins a course of two lectures on "Poisons and Antidotes." The Friday evening Discourse on April 8 will be delivered by Dr. R. H. A. Plimmer on "Quality of Protein in Nutrition," and on April 15 by Mr. Ernest Law on "Wolsey as a War Minister."

General Discussion on Failure of Metals.—A general discussion on Failure of Metals will be held on Wednesday, April 6, 1921, under the conjoint auspices of the Iron and Steel Institute, the Institution of Mechanical Engineers, the Faraday Society and the Institute of Metals, at the Institution of Mechanical Engineers, Storey's Gate, Westminster. There will be three sessions, commencing at 3 p.m., 5 p.m., and 8 p.m. respectively, with intervals for tea and dinner. Arrangements are being made to enable those attending to dine together at 6.45 p.m., at the Victoria Mansions Restaurant, 24, Victoria Street. Prof. Alfred W. Porter, D.Sc., F.R.S., President of the Faraday Society, will preside at the first session, when an introductory address will be delivered by Dr. W. Rosenhain, F.R.S., after which the Chair will be taken by Captain H. Riall Sankey, C.B., President of the Institution of Mechanical Engineers. Dr. J. E. Stead, F.R.S., President of the Iron and Steel Institute, will preside at the second session, and Eng. Vice-Admiral Sir George Goodwin, President of the Institute of Metals, will preside at the third session.. At each of these sessions a selection of papers will be submitted.

Possibilities of Power Production.—Prof. Burstall, Dean of Science at the University of Birmingham, and head of the mechanical engineering department, addressed the members of the Institute of Electrical Engineers on the "Possibilities of Power Production," at the University on March 17. The present period might determine, said Prof. Burstall, what he called the "carbon period," and the sources of power derived

from the combustion of carbon in the shape of coal and oil. The two latter were a sort of capital, upon which mankind would continue to live probably for the next 250 years, but the time would come when they would have to seek other sources of power. He thought it probable, however, that future generations would not want the great amount of mechanical power that we considered to be indispensable, and might deprive themselves of it quite voluntarily in favour of other methods. Regarding the possibilities of steam engines, he thought that in the next 50 years they might look to obtaining a horse-power hour for an expenditure of about 8lb. of coal, beyond which it was extremely unlikely that the thermodynamics of the steam engine would allow them to go. So far as they could see, the power generated by coal or oil would be sufficient for present conditions, but it was as well to look for possible new sources of power energy. The resources of cold water power were distinctly limited, and would not satisfy anything like the whole of the wants of mankind. That the power of the tides would be used he had not the slightest doubt, but it had never appealed to him that the generation of power from water was going to do anything more than merely scratch at the needs that would be felt. The windmill would certainly be used extensively in the future. They had virtually only one other method of working, and that had been there since the birth of the human race—the sun. The problem was: How are we going to use this energy in the form we wanted it?

Institution of Petroleum Technologists.—The officers elected for the session 1921-22 are as follows. *President*—Prof. John Samuel Strafford Brame. *Past-Presidents*—Sir Boverton Redwood, Prof. Sir John Cadman, Sir Charles Greenway, Bart., Sir Frederick W. Black. *Vice-Presidents*—Herbert Barringer, Sir George Beilby, Sir John Cargill, Bart., The Rt. Hon. Viscount Cowdray of Cowdray, Arthur W. Eastlake, Sir Thomas H. Holland. *Council*—Alfred C. Adams, Herbert Allen, Major R. W. Barnett, M.P., Andrew Campbell, E. H. Cunningham Craig, Alexander Duckham, A. E. Dunstan, James Kewley, W. R. Ormandy, T. C. Palmer, F. Mollwo Perkin, Robert Redwood, John S. Smith, Prof. W. W. Watts.

French Glass Industry.—A company formed in Paris under the style of the Compagnie Industrielle des Verreries à Vitre, with a capital of 14,900,000 francs, is building large works at Cussett, in the Allier, which, states the *Journal Industrielle,* will be the most important in Europe for the manufacture of window-glass, by the Fourcalt process. The works are to be constructed on the site of the Cussett bottle works, which during the war were converted into steel works by the Acieries et Forges de Firminy. It is hoped that the works will be ready in October next. The Société Industrielle is stated to have a considerable interest in the new concern, which has absorbed the Verreries Valentin Mesiner at Saint-Etienne. The new company has also acquired the works at Aniche (Nord) belonging to the Société Industrielle de Verrerie, which were partially destroyed during the war and subsequently rebuilt

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

8604—Adam, W. G.—Production of amino-phenols, etc. March 19th.
8334—Ballantine, W. B.—Manufacture of ferrochrome alloys. March 17th.
8302—Barrett Co.—Manufacture of formaldehyde. March 16th.
8393—Carpmael, W.—Manufacture of lithophones and barium hydroxide. March 17th.
8348—Green, R.—Compositions of cellulose acetate and nitrate. March 17th.
8515—Weight, O. W.—Manufacture of ammonium sulphate. March 18th.

Specifications published this Week.

136141—Carlsson, O. and Thall, E.—Methods of reducing the viscosity of viscous solutions of nitrous-cellulose and its compositions.
160114—Oswald, T. H. and Brown A. D. Dixon.—Apparatus for the extraction of oil from oleiferous sandstone shale or the like.

Abstract Published this Week.

Thorium Salts.—Mr. H. Wade of Hatton Garden, London, has recently been granted a Patent No. 156892 for an improved process of obtaining thorium salts. A salt having the composition $TH(PO_3)_2\ SO_4$ is obtained by heating at about 280°C. a solution of thorium sulphate to which has been added, phosphoric acid. After several hours the product separates as needle shaped crystals insoluble in water or dilute acid. Alternatively thorium phosphate may be heated with sulphuric acid or, for a less pure product, a native thorium phosphate such as monazite may be used, the new product separating out while the rare earths do not.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK.

Monday, April 4.

Royal Institution, 4.30. (General Meeting).
Society of Chemical Industry, 8.

Tuesday, April 5.

Royal Institution, 3. "Present Position of the Nebular Hypothesis," by Prof. R. A. Sampson.
Royal Society of Arts, 4.30.

Wednesday, April 6.

Faraday Society and other Societies, 2.30, 5 and 8. Joint General Discussion on the "Failure of Metals under Internal and Prolonged Stress."
Royal Society of Arts, 8. "The Optophone," by Dr. Archibald Barr.
Society of Public Analysts, 8. "Detection and Estimation of Illipé Nnt Fat used as a substitute for Cocoa Butter," by Francis G. H. Tate and John W. Pooley. "The Estimation of Strychnine in Scale Preparations containing Quinine and other Cinchona Alkaloids," by T. F. Harvey and S. Back. "A Colour Reaction for Aconite," by S. Mallaneh. "A Method for the Determination of the Acidity of Coloured Solutions," by J. L. Lizius.

Thursday, April 7.

Royal Institution, 3. "Thunderstorms," by Dr. C. T. R. Wilson.
Chemical Society, 8.
Institution of Electrical Engineers, 6. "Some Recent Developments in Steam Turbine Practice," by K. Baumann.

Friday, April 8.

Royal Institution, 9. "Quality of Protein in Nutrition," by Dr. R. H. A. Plimmer.
Physical Society, 5.

Saturday, April 9.

Royal Institution, 3. "Poisons and Antidotes," by Dr. H. H. Dale

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THE CHEMICAL NEWS.

VOL. CXXII., No. 3182.

A VOLUMETRIC METHOD FOR THE DETERMINATION OF LACTOSE BY ALKALINE POTASSIUM PERMANGANATE.*

By FELIPE T. ADRIANO.

Of the Laboratory of Agricultural Chemistry, College of Agriculture, University of the Philippines

QUISUMBING (F. A. Quisumbing, "Determination of Glucose and Starch by the Alkaline Potassium Permanganate Method," *Philip. Journ. Sci.*, 1920, xvi., 581), of this laboratory, recently devised a volumetric method for the determination of glucose and starch by alkaline potassium permanganate solution, which is claimed to be shorter than and as accurate as any of the Fehling methods, either gravimetric or volumetric. It was thought worth while to apply this method to the determination of lactose in milk. For this purpose a lactose permanganate table similar to that for pure lactose for glucose and starch was prepared. Parallel determinations of lactose in milk were then made by the new, the Soxhlet, and the optical methods. The results show that for the determination of sugar in milk the new method, besides being more rapid, promises to be as accurate as either of the older methods, if not more so.

Previous Work on Milk Sugar Determination.

So far as can be found in the available literature no quantitative method has ever been devised for the determination of lactose in milk by oxidation with potassium permanagante in alkaline solution. Greifenhagen, König, and Scholl (W. Greifenhagen, J. König, and A. Scholl, "Bestimmung der Kohlenhydrate durch Oxydation mittels Kaliumpermanganat in alkalischer Lösung," *Biochem. Zeitschr.*, 1911, xxxv., 177) determined the ration of lactose to the amount of oxygen used when the former is oxidised in an alkaline potassium permanganate solution, but they did not work out a method for the determination of this sugar in milk. Some determinations of lactose by the older methods are given here.

Woll (F. W. Woll, "Report on Dairy Products," *Bull. U.S. Dept. Agr., Bur. Chem.*, 1907, cv., 100) in his report on dairy products gives the following determinations of lactose in condensed milk :

Analyst.	Lactose. By gravimetric method. Per cent	By polariscope. Per cent
Jaffa and Stewart, California ...	9·28	9·36
Olson, Wisconsin	9·91	9·19
Jaffa and Stewart, California ...	8·11	8·00
Jaffa and Stewart, California ...	10·87	10·74
Jaffa and Stewart, California ...	9·96	9·84

He called attention to the fact that the results obtained with the polariscopic method are, in all cases but one, lower than with the copper reduction gravimetric method. His observations were confirmed by the report of Patrick and Boyle (G. E. Patrick and M. Boyle, "Sub-report on Analysis of Dairy Products," *Bull. U.S. Dept. Agr., Bur. Chem.*, 1907, cv., 106), who, in their sub-report on analysis of dairy products, gave the following results :—

Sample No.	Lactose By Soxhlet method. Per cent	By polariscope. Per cent
2930 (Referee's sample)	10·04	10·07
2530	10·51	10·19
2528	10·69	10·57
2610	10·15	9·97
2529	9·20	8·71
2531	9·37	9·00

Folin and McEllroy (O. Folin and W. S. McEllroy, "Copper Phosphate Mixtures as Sugar Reagents," *Journ. Biol. Chem.*, 1918, xxxiii , 513) have recently succeeded in introducing copper phosphate mixtures, the alkaline phosphate taking the place of tartrates, citrates, or glycerol in the analysis of sugars in urine, using a modified Benedict titration method. Folin and Denis (O. Folin and W. Denis, "The Determination of Lactose in Milk," *Journ. Biol. Chem.*, 1918, xxxiii., 521, 524) have applied this method to the determination of lactose in milk, and they claim that it gives accurate results. Their method as applied to milk is remarkably simple, for it does away with the preliminary preparation of protein-free filtrates, since albumin does not interfere with the titration, and it therefore "eliminates the cumbersome 'corrections' for the volume occupied by the protein-fat precipitates " In the same paper a picrate colorimetric method for lactose is described which is materially simpler than the one given by Dehn and Hartman (William M. Dehn and F. A. Hartman, "The Picrate Colorimetric Method for the Estimation of Carbohydrates," *Journ. Am. Chem. Soc.*, 1914, xxxii., 404). Parallel results obtained with the colorimetric method of Folin and Denis and the titration method are given to show that the latter is the more accurate.

Materials and Procedure.

Quisumbing's Method as Applied to the Determination of Lactose in Milk.—Place in an Erlenmeyer flask 50 cubic cm. of 0·1 *N* potassium of permanganate solution, 25 cubic cm. of a solution of sodium carbonate containing 8·48 grms. of (anhydrous) sodium carbonate per litre, and 5 or 10 cubic cm. of the filtrate obtained as indicated below. Add sufficient water to make the final volume of the mixture 100 cubic cm. Heat the mixture on the heating device, consisting of an iron tripod with asbestos hood, with the heating power so regulated that its temperature is raised from 29° C. to 95° C. in two minutes, and continue heating for another two minutes after the temperature has reached 95° C. Remove the flask and add gradually 25 cubic cm. of 30 per cent sulphuric acid and 0·1 *N* oxalic acid solution until the liquid is clear. Titrate the excess of oxalic acid against standard 0·1 *N* potassium permanganate solution, adding the latter until the liquid assumes a pink colour that remains for a few seconds. The sum of the number of cubic cm. of 0·1 *N* potassium permanganate solution used in oxidation and in titration minus the number of

* This investigation was undertaken at the suggestion and under the direction of Prof. M. L. Roxas. Published with the permission of the Director of the experiment station of the College of Agriculture, University of the Philippines.

cubic cm. of 0·1 *N* oxalic acid solution gives the number of cubic cm. of 0·1 *N* potassium permanganate solution that is actually used in oxidation. The corresponding lactose value with the use of pure lactose is shown in Table II.

The pure lactose used in obtaining the data for this table was prepared as follows:—

To an alcoholic solution, saturated at 40° C. of chemically pure lactose obtained from a local dealer, absolute alcohol and ether were added, and the sugar was allowed to crystallise from the solution in a vacuum dessicator over sulphuric acid. When about half of the solvent had evaporated, the crystals were separated from the mother liquor by suction and then washed with small amounts of ether and absolute alcohol. The lactose was recrystallised three times in the manner described and the purified product dried for 16 hours at 40° C. under vacuum in an apparatus similar to that described by Browne (C. A. Browne, "Handbook of Sugar Analysis," London, 1912, 23). Its purity was determined as follows:

1·6450 grms. of the pure lactose were weighed and dissolved to 100 cubic cm. 25 cubic cm. of this solution were analysed by the Soxhlet method for the lactose content, and a portion was polarised after having been allowed to stand for 24 hours.

Table I.—*Determination of the Purity of Lactose*

Method of analysis.	Lactose. Per cent.
Optical method	100·00
Soxhlet method	99·98
Average	99·99

Table II.—*Determination of Lactose by the Alkaline Potassium Permanganate Method.*

Lactose. mgs.	0·1 *N* $KMnO_4$. cc.	Lactose. mgs.	0·1 *N* $KMnO_4$. cc.
1	2·51	21	23·63
2	3·21	22	24·87
3	4·04	23	25·92
4	4·39	24	26·67
5	5·47	25	28·10
6	6·52	26	28·39
7	7·69	27	29·50
8	9·13	28	30·60
9	9·98	29	31·49
10	11·37	30	32·55
11	12·30	31	34·65
12	13·80	32	35·69
13	15·41	33	36·16
14	16·72	34	37·26
15	17·85	35	38·26
16	19·04	36	38·64
17	20·16	37	39·28
18	20·96	38	40·16
19	21·50	39	40·56
20	22·89	40	41·47

Application of the New Method to the Analysis of Lactose in Milk.

The milk under examination was analysed for its lactose content by means of the optical method, the gravimetric method, and the new method, thus making possible a comparison of the results of the three methods. That the milk samples should all be of equal concentration, the evaporated canned milk was diluted by mixing equal parts of the milk and water before proceeding with the analysis. To determine which of the methods is the most accurate, similar analyses were made on "synthetic" milk prepared as indicated below. The preparation of the solution used for the gravimetric method and the new method is as follows (Report of the Committee on Editing Tentative and Official Methods of Analysis, *Journ. Assoc. of Official Agri. Chemists*, 1916, Bulletins 1 and 2, 87, 104, 289):—

Dilute 25 cubic cm. of milk of known weight with 400 cubic cm. of distilled water in a 500 cubic cm. graduated flask. Add 10 cubic cm. of the copper sulphate (dissolve 34,639 grms. of copper sulphate in 100 cubic cm. of water and dilute to 1 litre) solution and 8·8 cubic cm. of 0·5 sodium hydroxide solution. After the addition of the alkali the mixture must still have an acid reaction and contain copper in solution. Fill the flask to the 500 cubic cm. mark; mix, filter through a dry filter, and determine the lactose in the filtrate, taking 50 cubic cm. for the copper reduction and 10 cubic cm. for the alkaline potassium permanganate method.

For the optical method the directions given in Sherman's "Organic Analysis," New York, 1912, 361, were followed.

The results of the analysis performed on canned and on fresh cows' milk are as follows:—

Table III.—*Determination of Lactose in Milk.*

(Figures express the percentages of lactose by weight.)

Sample. No.	Description.	Lactose. Polariscope: Per cent	Quisumbing's method. Per cent	Soxhlet's method. Per cent
1	Sterilised Norway natural milk	4·60	5·21	5·65
2	Ditto	4·56	5·20	5·64
	Average	4·580	5·205	5·645
3	Sterilised evaporated milk	6·12	9·52	9·76
a4	Ditto	8·26	9·88	10·08
a5	Ditto	7·28	9·70	9·88
a6	Ditto	7·22	9·84	9·86
	Average	7·220	9·735	9·895
7	Evaporated milk	8·71	9·98	10·30
8	Ditto	8·78	9·99	10·24
9	Ditto	8·72	9·94	10·30
10	Ditto	—	9·94	10·29
	Average	8·736	9·962	10·282
11	Sterilised natural milk	4·41	4·50	4·52
12	Ditto	4·42	4·46	4·62
13	Ditto	4·38	4·53	4·46
14	Ditto	4·38	4·46	4·73
	Average	4·395	4·487	4·582
15	Cows' milk from Los Baños	4·50	4·80	5·08
16	Ditto	4·48	4·79	5·06
	Average	4·490	4·795	5·070

a. These samples were taken from the same can as No. 3, but they were treated with varying amounts of pure lactose. The percentage of lactose added was subtracted to find the true percentage of lactose in the milk.

Analysis of Synthetic Milk.

For the purpose of determining which of the three methods will give the most accurate results, analyses were made of "synthetic" milk, which was prepared in the laboratory by mixing :—

	Per cent
Water	87·75
Fat (in the form of butter)	3·40
Protein (in the form of casein)	3·50
Pure Lactose	4·60
Mineral substances from the ash of canned milk	0·75

The results are shown in Table IV.

TABLE IV.—*Analyses of Synthetic Milk.*

Sample No.	Polariscopic method. Per cent	Lactose Quisumbing's method. Per cent	Soxhlet's method. Per cent
1	4·24	4·78	4·80
2	4·16	4·77	4·80
Per cent of lactose added	4·60	4·60	4·60

Discussion of Results.

Table II. gives the milligrms. of lactose corresponding to the number of cubic cm. of 0·1 *N* potassium permanganate solution used in the determination as described. Table III. shows the results of the analysis of the different samples of milk by the three methods. Table IV. gives the results with synthetic milk with a known percentage of lactose. From these tables it may be seen that the percentage of milk sugar given by the optical method is consistently lower than by the Quisumbing or the Soxhlet method, and also that the Quisumbing method gave lower results than did the Soxhlet. The differences between the polariscopic method and the two oxidation methods are in most cases serious, whereas the oxidation methods may be considered to agree closely. The differences between the polariscopic method and the two oxidation methods are greater in the case of the sterilised evaporated milk than in that of the sterilised natural milk or the fresh cows' milk (see Table III.). It was thought that the differences might be due to changes in the sterilised evaporated milk that occur during manufacture but which do not occur in the sterilised natural milk or in the fresh cows' milk, and that such changes resulted in the formation of soluble products not precipitated by acid mercuric nitrate. The proteins or milk are most susceptible to hydrolysis during the process of evaporation, and would give rise to optically active products which may not be precipitated by mercuric nitrate. To test this point the filtrates from samples 7 to 10, 11 to 14, and 15 and 16 (Table III.) were analysed for their nitrogen content by the Kjeldahl Gunning Arnold method (Report of the Committee on Editing Tentative and Official Methods of Analysis, *Journ. Assoc. of Official Chem.*, 1916, Bulletins 1 and 2, 87, 104, 289), with the following results :—

TABLE V.—*Nitrogen Determination of Filtrates from Samples 7 to* 10, 11 *to* 14, 15 *and* 16 (*Table III.*).

Source of sample.	Nitrogen in samples— 7 to 10 Per cent	11 to 14 Per cent	15 and 16 Per cent
Filtrate for the polariscopic method	0·0110	0·0130	0·0021
Calculated as mgrms. alanin in 100 cubic cm. of filtrate	70·00	82·50	12·70
Filtrate for the reduction methods	0·0006	0·0056	0·0016

These results show that hydrolysis of the protein occurs in the process of evaporation and sterilisation of milk. Thus the fresh cows' milk gives less nitrogen in the filtrate than either the evaporated or the sterilised milk. The differences are clearly seen if the nitrogen is expressed in milligrms. of a dipeptid or an amino acid such as alanin. Of course, nothing is known of the nature of these nitrogenous compounds. But, judging from the results of the analysis of samples 7 to 10, where the average difference between the polariscopic method and the two oxidation methods is greater than 1 per cent, and of samples 11 to 14, where the optical and the oxidation methods agree to within 0·1 per cent—both giving almost the same percentage of nitrogen in the filtrate—these soluble products may influence the rotation of lactose in either direction. It is very likely that other factors have an influence on the specific rotation of this sugar. This seems to be indicated by the results with synthetic milk. The casein used in the preparation of the latter must have been completely reprecipitated together with the fat by the acid mercuric nitrate, since hydrolysis of the casein was hardly possible under the conditions of the experiments; and yet the results of the sugar analysis by the polariscopic method are much lower than by the oxidation methods. Of course, no definite conclusions can yet be drawn from the results of only one set of experiments, but there are some indications that the mercuric nitrate, the ash, or the nitric acid, or all three, affect also the specific rotation of lactose. The influence of the factors seems to be cumulative in the case of the evaporated milk and compensating in the case of the sterilised milk.

Summary and Conclusions.

The attempt to apply the alkaline potassium permanganate method to the determination of lactose in milk has met with success. This method has advantages over the older methods in rapidity and accuracy. Lactose determinations run with the new method give consistently lower results than with the Soxhlet method.

The results obtained by the polariscopic method are very unreliable, and cannot be used for accurate work, especially in the analysis of canned milk. Where a high degree of accuracy in the results is required, the Quisumbing or Soxhlet method should be given preference.—*Philippine Journal of Science*, August, 1920.

HEALTH WEEK IN 1921.—The Secretary of the Health Week Committee, appointed by the Royal Sanitary Institute, announces that H.M. the King and H.M. the Queen have again graciously accorded their patronage to "Health Week," which will be held this year during the month of October

OVERGROWTHS ON DIAMOND.*

By J. R. SUTTON.

(Continued from p. 149.)

REASONING from the above results, the following conclusions, *venio rogatum*, would seem to be justifiable :—

Yellow ground contains more calcite than blue ground does.

Calcic carbonate in suspension, or solution, deposits itself readily in thin layers on a diamond surface, causing that surface to approximate to the consistency of the common minerals in the pulsator concentrates.

This deposit being more easily wetted than a bare diamond surface is, the surface tension in water is increased, and that in grease decreased accordingly. Hence the coated diamond behaves like an equal mass of limestone on the grease tables.

The above account is drawn with no material alteration from my report made at the time some years ago. This report had been put away and the details half forgotten, although the conclusions were alluded to in a recently-published paper. But during the last few months the results appear to have received some extraneous confirmation perhaps sufficiently important to warrant the publication of them. This latter development will now be briefly described.

Now it is to be noted that if calcite, or limestone, can be made to form a crust on a diamond by artificial means, it ought to do the same naturally, in propitious circumstances. So far as the Wesselton yellow-ground diamonds are concerned, since they do not always adhere readily to the grease tables, this would appear to have been proved, or at least made probable, by the experiments described above. But since calcite occurs in fair abundance in some specimens of blue ground, there ought to be cases here and there in which blue-ground diamonds had acquired a calcite coating. The chances would be, however, that even so it would not follow that the coating would survive the rough treatment of mining and winning to the end at the grease tables. Moreover, should it be a thick coating and completely enclose a diamond, and survive intact, the diamond would certainly be rejected by the grease tables like the superfluous concentrates; or, in case of dry sorting, probably rejected as a valueless piece of white mineral. The chances are, therefore, not altogether favourable for the detection of a diamond with a thick coating. Nevertheless, diamonds heavily coated with a more or less complete shell are occasionally found. They come mostly from the interesting Bultfontein Mine, doubtless partly because the prevailing striated surface of Bultfontein diamond holds the coating best, and partly because of the abundance of calcite there; but they are found occasionally at Wesselton and Dutoitspan.

A significant fact about these particular lime-coated diamonds from blue ground is that the coating is not aragonite. For when it is boiled with cobalt nitrate it remains uncoloured. It is evident, therefore, that the coating was acquired at a late stage in the history of the matrix, and at a low temperature.

* From the Transactions of the Royal Society of South Africa.

Equally significant is the fact that calcite is not found inside cracked diamonds from the Kimberley area. The filling material has been taken from the cracks of many diamonds on the De Beers sorting tables and in no case has it been calcite. Usually it appears to be apophyllite ("The Diamond Mines of South Africa," p. 507), and pectolite has been found. Hence it may reasonably be inferred that the cracking of the diamonds took place at a relatively early period, and that the cracks became filled with a zeolite, or something of that sort, before the calcite was introduced, or separated out, into the matrix (F. P. Mennell, "The Miner's Guide," 1909, p. 147; also P. A. Wagner, "The Diamond Fields of Southern Africa," 1914, p. 75). Which is yet another argument against the popular delusion that cleavages among diamonds are due to explosion after the diamonds are taken from their matrix.

Occasional Dutoitspan rounded yellow diamonds are reported which have failed to adhere to the grease tables. They carry no obvious foreign coating any more than the Wesselton yellow-ground diamonds did, but presumably they carry a coating even though it be indefinitely thin. And it may be surmised that they come from the vicinity of local accumulations of calcite in the pipe rock. One typical specimen that had been rejected by all three tables adhered to the grease quite normally after immersion in a weak acid.

It may be of interest to quote here some remarks made by Boutan in his great work "Le Diamant," 1886, p. 171. Speaking from actual experience of Kimberley as it was somewhere about 1884—i.e., at a time when the blue ground had been reached and was being worked, he says of the diamond :—

"Il se présente sous bien des états divers de cristallisation, de couleur et de grosseur; mais il est presque toujours envelloppé d'une mince pellicule calcaire, qu'on enlève avec les autres impuretés qui pourraient ternir sa surface en le laissant pendant quelque temps dans de l'acide azotique bouillant."

It is a curious statement to make, however, that diamonds fresh from the mine were almost always encased in a chalky envelope (G. F. Williams, p. 208: "All the crystals in the blue ground were encased in a smooth bed of the same material, which did not adhere to the diamonds, so that their lustre, when extracted, was quite bright or glassy."). Certainly diamonds have always been put into acid—mostly aqua regia earlier, though hydrofluoric nowadays—before being sorted for shipment to London; but, as one understood, rather to remove impurities from cracks than especially to clean their surfaces, though of course it would do that too. And yet one hesitates to question the word of so careful a writer as Boutan. Possibly the explanation of the difficulty is either that such diamonds as he had the opportunity of seeing were thus coated, or that he mistook the main purpose for which the acid was generally used. True or not, the copyists lost a chance in not repeating the statement and so passing it on by their unanimity to the realm of historical fact. It may be mentioned here that it is well known at the De Beers pulsator that diamonds which have been lying for many years in the blue ground on the depositing floors are very intractable on the grease tables. Probably the long - continued

weathering has set calcite free, either from the blue ground itself or from the limestone underlying the floors, to form an incrustation on the diamond.

A clean diamond is not readily wetted by ordinary rain or river water. If it be immersed in such water it will come out dry saving where droplets can cling to irregularities upon its surface, and even these are easily shaken off. A triangular flake of diamond whose edges are 12 mm., and whose thickness is 1·25 mm., will float indefinitely upon a still-water surface. If the same flake be placed edge downwards in the water whose depth is about 6 mm., the lower edge will rest at the bottom of the water, and the top corner will project slantwise through the surface, and remain so, provided that the surface is kept fairly quiet. This is the largest thin flake there has been the opportunity to try, though doubtless much larger ones would behave in the same way. Small diamonds of good geometrical form up to at least 0·1 carat each will float on water, even when it is gently agitated, like corks, partly because of the surface tension of the water, but chiefly because they are not readily wetted, whereas most common minerals of the same size will submerge at once.

A number of simple experiments have been made with the object of ascertaining whether the addition of freely soluble substances to water would modify the surface tension between diamond and water. Saturated solutions of the following compounds showed no appreciable difference: Alum, Epsom salts, sal ammoniac, common salt, saltpetre. Saturated solutions of the following increased the tension somewhat: Chloride of lime, borax, hyposulphite of soda. On the other hand, a solution of caustic soda wetted the diamond thoroughly. But of all the substances tried, carbonate of soda proved by far the most effective. A diamond (crystal or bort) dipped into a saturated solution of carbonate of soda comes out wet and dries with a thick deposit of the substance. Even here, however, the wetting tends to be to a certain extent selective. The deposit as a rule dries thicker on the faces of the octahedron than it does on the edges; and, by the same token, thicker on the edges of the rhombic dodecahedron than it does on the faces. Some octahedra dry with their faces thickly coated (saving where deep triangular indentations interfere) and their edges scarcely dimmed, and some dodecahedra dry with their edges sharply outlined in white. This result may arise from faulty manipulation, or it may have been accidental to the limited number of stones treated; but it is curious that the observer occasionally comes across a diamond naturally coated on its octahedron faces with a black adamantine incrustation, while its edges are so clear that the colourless interior can be seen through them. On the other hand, a bort incrustation favours the dodecahedron faces of Wesselton "black" (nearly opaque) diamond.

One other, minor, point: If a diamond be placed in a solution of carbonate of soda contained in a glass vessel, the soda, in spite of its affinity for the diamond, will crystallise out, as the water evaporates, by preference on the sides of the vessel above the water surface, while the diamond remains uncovered in the solution. But in a solution of cane-sugar crystallisation will begin on the diamond alone, and the latter after a time will appear as if enveloped in an extensive cloudy condensation. The reasons need not detain us.

Coated Diamonds: Some Observations and Inferences.

Diamonds with a black incrustation are common, especially at Wesselton. In the mines of the Kimberley area this incrustation is usually very thin, and under magnification is seen to consist of minute dull black specks, more or less uniformly streaked over a somewhat rough and pitted surface—so thin, indeed, as to make the diamond look slaty-grey by reflected light, and smoky-brown by transmitted light. Not improbably this coating is allied to the frequent black spots included in the body of spotted stones. Whether, so far as the Kimberley mines are concerned, it represents the remains of a thicker coating which has been lost either naturally or in the process of mining and winning is doubtful. Mr. P. Ross Frames, however, has obtained, at the Premier Mine, Pretoria, a small diamond from the midst of a lump of graphite, and at this mine diamonds with quite a thick, soft black coating are sometimes found (P. A. Wagner, "Note on Graphite-coated Diamonds from the Premier Mine," *Trans. Geol. Soc. S.A.*, 1914; also "The Diamond Fields of Southern Africa," p. 143). The black coatings of the Kimberley area diamonds may be amorphous or crystalline diamond, or even graphite like the Premier ones. It may be due to a temporary increase of temperature in past time. But a sufficiently great general increase of temperature is not very likely, if only for the fact that diamonds are found in intimate association with crystal garnet and coloured zircon. Of bort the same may be said; and quite recently a lump of stewartite containing numerous grains of almandine garnet was found at Bultfontein. High temperatures would be expected to render the garnet vitreous and to blanch the zircon.

The black incrustation is more likely to be a late corrosive sort of deposit on the diamond, quite independent of the process of crystallisation and not defining its final phase. And this view is supported by a small broken lump found at Koffyfontein which at first sight resembles a fragment of coal, but on closer examination proves to be transparent diamond thickly encrusted with a very hard black adamantine coat. It cannot be denied that the fracture preceded the incrustation.

This Koffyfontein specimen, then, helps us to see that the black spots common in diamonds have not necessarily always been enclosed within rapidly and continuously crystallising diamonds; and still less are these same spots centres of crystallisation in a metastable medium, but rather are incrustations on temporarily quiescent diamond surfaces analogous to the lime coatings dealt with above. For, suppose some black incrustation to form spots on a diamond crystal, then a further stage of diamond crystallisation would determine the black spots as inclusions like other minerals, such as garnet, pyrites, &c., captured in the same way. And this no doubt explains the frequent colour effects in their vicinity revealed by the polariscope. Also it helps us to

see that Dutoitspan rounded yellow diamonds, which are much less subject to strain and are less spotted than most other kinds, were probably formed more rapidly in one continuous process.

Haüy, indeed, attributed the rounded form of some diamonds to rapid crystallisation :

"Mais la formation du diamant ayant été précipitée, les faces ont subi des arrondissemens, comme cela arrive par rapport à une multitude de minéraux" ("Traité de Minéralogie," 1801, iii., p. 290). (Antonio Magliabechi expressed the opinion that diamonds do not grow larger by lying in the earth, but that their magnitude and figure are assumed at once (*Phil. Trans.*, 1707, No. 311). Leuwenhoeck gives reasons for thinking differently (*ibid.*, 1709, No. 324). But crystallisation fast or slow, necessarily postulates a solvent).

Whole stones encrusted in precisely the same way are met with now and again in the mines of Griqualand West. More important still, encrusted stones have been proved to exist inside larger ones. A good and typical instance was a Dutoitspan fragment of about two carats consisting of about a third of a whole white rounded diamond. Portions had split away from the original whole stone along two octahedral planes of cleavage, showing near the middle of the edge where the cleavage planes met a heavily encrusted little stone of fair form, as depicted on an enlarged scale in the annexed Fig. I. The incrustation was at least as hard as ordinary diamond. Observed through what was left of the natural face the inside of the fragment appeared to be extensively blurred with large black blotches —an illusionary effect caused by refraction, for actually, saving for the encrusted inclusion, the specimen was quite without blemish. Soft graphite inclusions are plentiful enough in the holes so common in the cleavage surface of diamond.

Owing to the high refractive index and frequent rounded habit of diamond, the true outlines of black spot inclusions are not always easy to make out, but frequently they seem to be shapeless. Sometimes they are mere flakes. They occur either singly or in groups. Jagersfontein diamonds are noted for the dense and solid appearance of their large black spots. At the other end of the scale of size are the smoky-brown clouds— the danger-signals of sensational literature, giving warning of impending explosion !—clouds of tiny black discrete particles. One would like to understand how the internal black spots are aligned with respect to the space lattice, as to which there is a striking suggestion in the case of a coated Bultfontein "rounded octahedron," within which at a depth of about a millimetre (as determined roughly by the focussing distance) under one face were three separate constellations of tiny black spots all lying in one octahedral plane of cleavage (two observations of a similar kind made by Des Cloizeaux, and cited by Boutan). These constellations of spots were of additional interest because of the gorgeous chromatic display they gave under the polariscope, and also for their obvious relationship to the surface markings, for exactly over each constellation was a particularly well-defined indented triangle. Could the millimetre or so of the face have been cleared off, then without a doubt the new face would have had much the same sort of coated appearance as the existing natural face had.

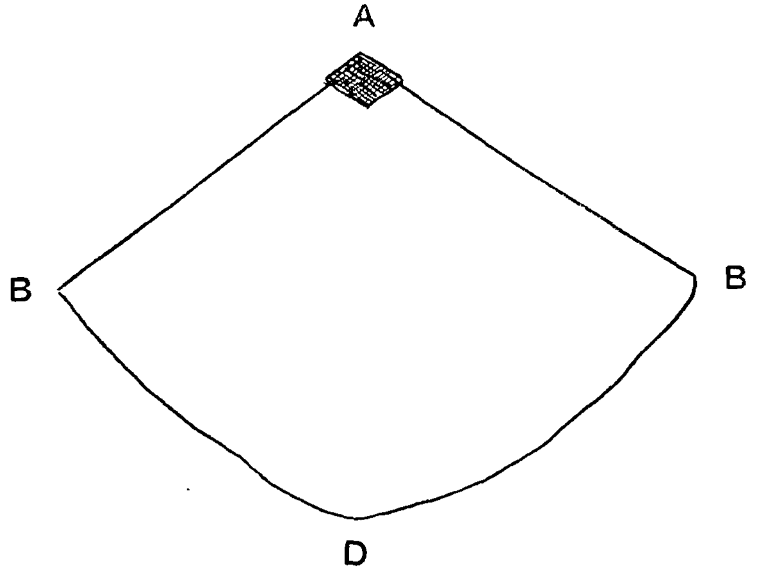

FIG. I.—Section of fragment showing position of inclusion.
A. Encrusted inclusion. AB. Cleavage faces. BDB. Natural surface.

(To be continued.)

DIGITALIS LEAVES.—According to the physiological test, the activity of the digitalis leaf seems to decrease with age of the plant, differently to current opinion. Desiccation plays an important part, and a plant rapidly dried at 60° C. loses none of its activity (Ioachimoyla).—*Bull. Soc. Chim. de France*, January 20, 1921.

SPIDERS USED IN MEDICINE.

By J. T. LLOYD, Ph.D.
Cincinnati, Ohio.

THAT insects and their by-products, such as shellac and honey, play an important part in the economy of man, is known to all. Perhaps, however, it is better known to the physician than to the layman, that a few spiders play their role in the practice of medicine. These spider remedies, like the insect medicines, are not of modern origin. In old works one finds frequent references to cobweb, which was then administered in the form of pills instead of the modern alcoholic pharmaceutical preparation, Tela Araneæ.

In the popular mind there is often little knowledge of the distinctions between spiders and insects, although the class *Arachnida* (to which the spiders, but not the insects, belong) contains several orders, such as the scorpions, that are closer akin to the spiders than are the insects. Most of these are so distinct in superficial appearance that there is little probability of their being mistaken for spiders.

If one will remember that spiders have four pairs of legs, apparently no antennæ, and that their head is not separated from the thorax by a neck-like constriction, there need be no trouble to distinguish them from insects; which have three pairs of articulated legs, one pair of antennæ, and head and thorax separated by a distinct "neck." In the class Arachnida, spiders may be easily separated from other orders by remembering that thorax and abdomen are separated by a short, slender stalk, and the abdomen is not segmented. In their nearest relatives, the mites, the thorax and abdomen are fused and sack-like.

Since very early times many people have looked upon spiders with unfounded dread and superstition. During the medieval period, "Tarantism," a contagious disease that was common in Southern Europe, especially Italy, was believed to have been started by the bite of a spider. The victims of this disease were possessed with an uncontrollable desire to dance. In our own day and among our own people it is not unusual to blame the bite of a spider for swellings or itchings of unknown origin, but when questioned the sufferer is invariably unable to give other evidence that a spider is responsible for the trouble, than the usual answer, "What else could have done it?" On this negative evidence the blame is fixed for about 100 per cent of the "spider bites" of our people.

With the possible exception of a single species in our Southern States (*Lactrodectus mactans*, a jet-black spider with markings of yellow or red), and the true tarantulas of the South-West, it seems safe to accept that there are no spiders in our country whose bite need be in any way feared. The writer has handled large numbers of our native spiders, as well as (during excursions in the tropics) hundreds of the "banana tarantulas," which are not true tarantulas, but harmless spiders of a different family. True tarantulas may sometimes, however, be found in banana bunches. In no case has the writer been bitten, and frequent attempts to induce spiders to bite the tender skin between his fingers resulted in failure. Others who have made this experiment with success report that the wound inflicted is no more painful than a slight prick with a needle. That spiders do inject a virus into their victims is indisputable, but it is in quantities sufficient only to paralyse an insect. Besides, is is injected so slowly that little, if any, could be secreted during the short interval that the "jaws" remain in the wound of an animal as large as man.

Spider Web.—All species of spiders are capable of spinning web, though far from all spin orbs or sheet-like webs for entrapping prey. Many species only throw out a "drag line" as they move from place to place, or drop from surface to surface, and never spin a more complex web, except in wrapping their egg masses.

The web material, or silk, is produced in large glands within the spider's abdominal cavity. In the glands the material is liquid or mucilaginous, but (except certain parts of the viscid silk) immediately hardens on exposure to the air. From the glands it passes to the exterior through silk ducts, which often open on movable, finger-shaped "spinneretts."

In all, spiders produce seven distinct kinds of silk; some thread-like, some band-like, some viscid, some dry. Though most spiders secrete more than one kind of silk, and some spiders secrete several kinds, no one spider secretes all seven. Each kind of silk originates in its own distinct glands and passes to the exterior through its own opening. (A careful and interesting account, written in non-technical language, of the habits, anatomy, and classification of spiders, may be found in "The Spider Book," by John Henry Comstock: Doubleday, Page & Co., 1912).

For pharmaceutical preparations an attempt is made to collect the sheet-like webs of *Coras medicinalis* (*Tegenaria medicinalis*) from the corners of rooms in warehouses and kindred places. It is probable, however, that the webs of the several species of dwelling-inhabiting spiders enter into all pharmaceutical preparations of web. No collector of webs could be expected to possess technical knowledge sufficient to enable him to distinguish species. If he should possess the required knowledge, it would be impracticable for him to take the time to apply his training for the examination of each web collected. Nor is there need for such discrimination. No reason why the web of one species of dwelling-inhabiting spider should be of different therapeutical qualities from another, has ever been recorded.

We do not know that a chemical analysis of spider web has ever been made. Tests given pharmaceutical preparations, however, show an absence of sugar, but give a slight reaction to Mayer's test for alkaloid. This is true also of tincture we have prepared from fresh web. The therapeutic value of the preparation may be in part due to this alkaloid.

In the present-day practice of medicine the large spiders of the sub-family *Aviculariinæ*, commonly known as "tarantulas," or "bird spiders," are employed by Homœopathic physicians. Under the name of *Mygale lasidora* the Pharmacopœia of the American Institute of Homœopathy, 1897, p. 408, gives directions for preparing the tincture of the "whole spider." Other references to the preparation and use of Mygale (tarantula) are given in Allen's "Encyclopedia of Pure Materia Medica," 1877, vol. vi., and elsewhere.

Spider and Spider Web in Medicine.—At least since the time of Pliny (first century A.D.) literature on medicine abounds in references to the use of spiders and their webs. The ideas of most of the old authors concerning the medicinal use of spiders, as may be noted in the following quotations, seem little more than "charm medicine" or superstition. Let us quote :

Spiders. "The fly-catching spider, wrapt in a linen cloth and hanged on the left arm, is good to drive away a Quotidian, saith *Trallianus* (sixth century, A.D.). But better if any of them be boiled with oil of bay to the consistence of a liniment; if you anoint the arteries of the wrists, the arms and temples before the fit, the fever abates and seldom comes again. *Koronides or Koranus* (King of Persia, who wrote a work on natural history). A spider bruised with a plaister and spread on a cloth and applied to the temples, cures a tertian. *Dioscorides* (first or second century, A.D.). The spider called Lycos, put in a quill, and hanged on the breast doth the same. *Pliny* (first century, A.D.). That house spider that spins a thick fine and white web, shut up in a piece of leather or a nut-shell, and hanged to the arm or neck, is thought to drive away the fits of a quartane. *Dioscorides* saith he proved it to be true. Three living spiders put into oil, let them presently boil on the fire, drop some of that oil warm into the ear that is in pain, and it profits much. Or press out the juice of spiders with juice of roses, and put it in with wool. *Marcellus Empiricus* (380-408, A.D., or later). Pliny bids infuse them in vinegar or oil of roses and stamp them and then drop some into the ear with saffron, and it will still the pain certainly : Dioscorides affirms as much. *Sofratus* . . . saith, that Cranacolapsus (a certain spider) drowned in oil, is a present remedy against poisons, as the Scholiast of Nicander (second century, B.C.) professeth. Aetius (about 500 A.D.) for suffocation of the mothers, applied a cerate of spider to the navel, and said it did great good."

Spider Web. "The spider's web is put into the unguent against Tetters, and applied to the swellings of the fundament, it consumes them without pain. *Marcellus Empiricus.* Pliny saith it cures runnings of the eyes, and laid on with oil, heals up wounds in the joints. Some rather use the ashes of the webs with Polonia and wine. Our chirurgians (surgeons) cure warts thus : They wrap a spider's ordinary web into the fashion of a ball, and laying it on the wart, they set it on fire, and so let it burn to ashes, by this means the wart is rooted out by the roots, and will never grow again. Marcellus Empiricus was wont to use the web of spiders found in the Cypress tree in a remedy for the Gout to ease the pains."—Mouffet, "The Theater of Insects," 1858, p. 1023.

A few of the early writers, like Antoninus Pius, and more during the medieval period, used the web to stop the flow of blood. For this purpose it was also used by the American Indians, as well as in domestic practice, no doubt with a real value. For example :

"Antoninus Pius (86-161, A.D.) was wont to say, that the quirks of sophistry were like to Spiders' Webs, that had a great deal of art and ingenuity in them, but very little profit. But how often hath the blood run forth from the body most miserably by a fresh wound? Yet it had been easy to have stopped it by laying on a spider's web."—Mouffet, "The Theater of Insects."

"*Telia Aranearum*, Cobweb. Everyone knows what this is, and how produced. It appears not in medicinal prescriptions, but as accident, for want of other helps, has taught its use to common people for stopping blood in a fresh wound. And this it seems to do by its extraordinary fineness; which makes it adhere to, and top up the mouths of the vessels, so as to prevent the effusion of their contents."—Quincy's Compleat English Dispensatory, 1749.

"*Aranearum Telae Pharm. Edinb.*, Cobwebs.—These are applied by the common people for stopping the bleeding of wounds; which the effect, not by any styptic power, but by adhering to the part, and closing the orifices of the vessels."—Lewis' Materia Medica, London, 1768.

"The web astringes and conglutinates, and is, therefore, vulnerary; restrains bleedings, and prevents inflammation. The country people have a tradition, that a small quantity of spider's web, given about an hour before the fit of an ague, and repeated immediately before it, is effectual in curing troublesome, and sometimes obstinate distemper. This remedy is not confined to our own country, for I am well informed that the Indians about North Carolina have great dependence on this remedy for agues, to which they are much subject; and I am acquainted with a gentleman long resident in those parts, who assures me he was himself cured by it of that distemper. And, indeed, experience confirms the efficacy of this medicine in the cure of agues."—James, "New English Dispensatory, London, 1747.

In May, 1809, the *Medical and Physical Journal* of London published a long article by Dr. Robert Jackson, calling to the attention of the profession the medicinal use of spider web, or cobweb, in the treatment of intermitting fevers. Frequent references have been made to this article by subsequent publications in Europe and in America. After Dr. Jackson's publication, the use of spider web in the treatment of malarial fevers seems to have been neglected until about 1865, when articles by Dr. L. M. Jones appeared in the *Lancet and Observer*, Cincinnati, and in Jones and Scudder's "Materia Medica." These again brought it to the attention of physicians :

"In asthma it is said to allay irritation, tranquilise the system, and act like a charm. In spasmodic complaints of females; in chronic hysteria, and other diseases attended with morbid irritability of the nervous system, it has been advantageously employed. Dr. Webster, of Boston, has found it beneficial in rheumatic affections of the head, asthma, and chronic coughs. He says it produces a pleasant delirium and exhilarating effects resembling the nitrous oxide gas. Dr. Gillespie used it in obstinate intermittents successfully, after other remedies had proved ineffectual. He thinks it more effectual than bark, arsenic, or any other remedy he has employed.

Dose.—Gr. v to vj, in pill; repeat every three or four hours. Dr. Jackson thinks a dose of gr. v produces nearly the same effects as one of gr. xx."—Jones and Scudder's "Materia Medica."

After the articles by Dr. Jones, the use of web gained constantly in the favour of many physicians. Present-day literature contains numerous testimonials to its use in the treatment of inter-

mittent fever, and in diseases of sudden appearance, when there is a tendency to congestion, with cool clammy skin, cool extremities, and cold perspiration.

Among the patients of the late Dr. L. A. Perce, of Long Beach, California, were many tourists afflicted with malaria. Some of these had been, to use his words, "dosed with quinine until it had lost its effect." For such patients he states that he employed tincture of "Tela Araneæ,' with gratifying results.

Until comparatively recently, as already stated the web was administered in the form of pills, instead of in the alcoholic pharmaceutical preparation, "Tela Araneæ," of the present day.—*American Journal of Pharmacy*, January, 1921.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

March 17, 1921.

Prof. C. S. Sherrington, President, in the Chair.

The following papers were read:—

"The Colour of the Light from the Night Sky." By Lord Rayleigh, F.R.S.

To get information as to the chromatic character of the light from the sky at night, photographic exposures were made under coloured media selected for isolating various parts of the spectrum. By comparing the photographic densities obtained, it was concluded that the night sky was much yellower or less blue than the (clear) day sky. Comparison with direct sunlight or moonlight showed that the night sky was of the same quality as these.

Visual comparisons through coloured films showed that a blue film, which was equally bright with a yellow one against the night sky, was brighter against the twilight sky. These comparisons were not embarassed by colour differences, because the light was so faint as to give purely monochromatic vision. The two films matched one another equally well, whether they were seen against the Milky Way or against other parts of the sky. In the photographic work no special attention was paid to this point, the exposures being made to a considerable area of sky around the zenith. The diurnal motion, of course, brought successive areas of the sky into action during the long exposures.

One theory of the light of the night sky attributes it to sunlight scattered by a very rare gaseous atmosphere, situated so high up as to be outside the earth's shadow. The present observations are contradictory of this theory, which would require the night sky to have the same colour as the day sky.

The requirements, as regards colour and polarisation of light, would be satisfied if we regarded it as coming from an unresolved background of stars. They would equally be satisfied if we regarded it as due to sunlight scattered by meteoric matter.

"The Dissipation of Energy in Permanent Ocean Currents, with some Relations between Salinities, Temperatures, and Currents." By R. O. Street.

On the assumption of slow non-turbulent motion a formula for the mean rate of energy dissipation in permanent ocean currents is obtained, which when integrated over the whole of the oceans, gives a dissipation at the mean rate of approximately 3×10^{18} ergs per second. Simple relations between the strength of the current and the salinity and the temperature of the water are also found; and it is shown that, even with the scanty data available, satisfactory estimates of the currents in mid-ocean can thus be made.

"The Vacuum Arc Spectra of Sodium and Potassium." By S. Datta.

Definite improvements in the measures for the spectra of sodium and potassium have been obtained by the use of sodium and potassium vapour lamps as sources. The lamps were excited in the manner described by Lord Rayleigh in his Bakerian Lecture in 1919, and they gave extremely narrow bright lines, such that the term diffuse, as applied to one of the series, becomes a misnomer. With potassium, an interesting combination pair indicating satellites to the diffuse series has been observed. The presence of potassium in the sun has been established, and some additional sodium lines have been identified with solar lines.

"Heats of Combustion and Formation of Nitro-compounds. Part I.—Benzene, Toluene, Phenol, and Methylaniline Series. By W. E. Garner and C. L. Abernethy.

The adaptation of aromatic nitro-compounds as explosives for military purposes has necessitated a close investigation of certain of their properties, of which sensitiveness of impact, stability, and power are the most important. These properties are, however, fundamentally related to the heats of formation and heats of combustion of the various compounds, and as but few systematic investigations had been made of these constants, a more complete study has been attempted.

In this paper, the heats of combustion of all the isomerides of the mono-, di-, and tri-nitro toluenes, and of the mono-, di-, and tri-nitro benzenes, together with a number of nitroderivatives of phenol and methylaniline, have been determined, and the heats of formation and nitration calculated therefrom. The heats of formation and nitration of the isomerides of the di- and tri-nitro toluenes and benzenes show considerable variation, the values tending to a minimum when the nitro-groups are adjacent to one another or to a methyl group. An empirical relationship has been established connecting the heats of formation and the orientation of the nitro groups, which holds approximately for these compounds.

The heats of formation in any series increase to a maximum value, with the introduction of the nitro groups, this maximum being reached in the toluene, phenol, and methylaniline series (when symmetrical substitution takes place) at the di-nitro derivative. The introduction of the methyl group into benzene modifies only slightly the shape of the curves showing the heats of formation of the derivatives, but the hydroxyl or methylaniline group has a much greater effect. The

parallelism between these derivatives of phenol and methyl aniline is very marked.

The high heat of formation of picric acid, 63·3 cal/mol, as compared with that of tri-nitro toluene, 29·1 cal/mol, provides an explanation for the very similar heats which are liberated in the detonation of these substances. The lower oxygen content of tri-nitro toluene is counter-balanced by its lower heat of formation. For a similar reason the unsymmetrical isomerides, though less stable and more sensitive than the symmetrical forms, should be more powerful explosives.

"The Catalytic Dehydrogenation of Alcohols." By E. K. Rideal.

Application of the approximation formula of the Nernst heat theorem to the equilibria

$$C_2H_5OH \rightleftarrows CH_3CHO + H_2 \text{ and}$$

$$(CH_3)_2CHOH \rightleftarrows (CH_3)_2CO + H_2$$

indicates that the dissociation constants should vary extremely rapidly with the temperature. The variation of the constants with the temperature was determined experimentally by means of a constant volume gas thermometer containing reduced copper as catalytic material. The velocity of decomposition of the alcohol at the surface of the solid catalyst was found to be much more rapid than the reverse bimolecular reaction. Concordant values for the equilibrium constants at various temperatures could only be obtained at low pressures. At elevated pressures and at high temperatures various secondary reactions occur which appear to be irreversible under the experimental conditions.

In the case of ethyl alcohol the value of K_p was found to vary from $6{\cdot}44 \; 10^{-4}$ at 125° C. to 0·91 at 275° C.; for isopropyl alcohol the respective values were found to be $2{\cdot}82 \; 10^{-3}$ and 12·00 respectively.

The value of ΔU_0 for the dehydrogenation of ethyl alcohol was found to be 11,500 cal. per grm. molecule, whilst the value calculated from the mean of the published values of the heats of combustion was found to be 10,700 cal. For isopropyl alcohol ΔU_0 was found to be 20,100 calories per grm. mol.

SOCIETY OF GLASS TECHNOLOGY.

The March meeting of the Society of Glass Technology was held in Newcastle-on-Tyne on Wednesday, March 16, 1921. In the forenoon, by the courtesy of the directors, a visit was paid to the works of Messrs. Lemington Glassworks, Ltd., Lemington-on-Tyne. The party was conveyed to and from Newcastle by char-a-bancs, also also kindly provided by the Directors. At Lemington, members were met by Mr. C. Wilson (Managing Director) and Mr. W. W. Warren, A.M.I.C.E., A.M.I.E.E. (General Manager) A most interesting time was spent watching the processes in the manufacture of electric lamp bulbs and of glass tubing. Of special interest were the Westlake machines. This is an American automatic bulb-blowing machine, capable of turning out 1000 bulbs per hour The workmen call it the "Iron Man." As the hand process was also in operation close by, the contrast between the two methods was the more striking. Messrs. The General Electric Co., Ltd., London, are the proprietors of the Lemington Works, the bulbs being sent to London to be completed.

Prior to the afternoon meeting, members of the Society were the guests at luncheon of the directors of Messrs. Lemington Glassworks, Ltd. A most enjoyable time was spent Mr. C. Wilson presided, supported by Prof. W. E. S. Turner, Dr. Travers, Mr. W. W. Warren, and a number of local glass manufacturers. Replying to a vote of thanks proposed by Dr. M. W. Travers, Mr. C. Wilson observed that apart from Lemington, the British glassmaker had hardly produced a bulb worth the name. He believed there was a fine future before the trade if only glassmakers would realise that they could not continue to work by rule of thumb, but must adopt the most scientific methods. The trade was bound up in science, and glassmaking was becoming more and more an engineering problem. It was also necessary that the workmen should realise that the success of the trade depended upon them as much as upon the employer. Mr. W. W. Warren also spoke eulogising the Westlake machine. He said he and his staff were out to make their works as efficient as any on the Continent or in America He claimed that they had already gone a long way towards attaining that object.

Prior to the reading of the papers at the afternoon meeting, the Chairman, Dr. W. M. Travers, paid a tribute to the work of the late Lord Moulton. Just a few days before his death, Lord Moulton had agreed to preside at the Annual Dinner of the Society to be held at the Hotel Cecil, London, on the evening of Wednesday, April 20. It was resolved unanimously that the Society record on its Minutes its appreciation of the great services rendered to science by Lord Moulton, and a vote of condolence with his family was passed, the members standing to record their sympathy in silence.

The following papers were read :—

"Note on the Corrosion of Fireclay Refractory Materials by Glassmaking Materials." By Donald Turner, B.Sc.Tech., and Prof. W. E. S. Turner, D.Sc.

The research in question, said Prof. Turner, was an attempt to obtain information as to the relative attack of batch materials on fireclay refractories. The results were of much interest, and scarcely in keeping with some traditions. It was found that even at 800°, soda ash attacked fully-burnt fireclay, and particles of a certain size lost between 11 and 18 per cent of their weight in the space of three hours. Again, whereas soda ash was so corrosive, saltcake was not nearly so active, and in comparative tests took up no more than 1 per cent of the fireclay at 800°. The results indicated that the temperature of decomposition of the alkaline salts influenced their corrosiveness, those decomposing at lowest temperatures, such as nitrates, being most corrosive. The need of thorough batch mixing was also emphasised, as any segregation of the alkaline salt made it more likely that corrosion would occur.

"The Clouding of Glass." By M. W. Travers. D.Sc., F.R.S.

This research was intended to determine the causes of the clouding of soft soda glass during

lampworking operations a short distance from the hottest zone. He showed that when pure hydrogen and air were used there was no clouding effect, and hence came to the conclusion that some impurity in the gas was an important factor in causing clouding. Further experiments showed that sulphur dioxide when present in the gas in more than a very small proportion, was the chief factor in producing this effect. Theoretical considerations also pointed to the probability of sulphur compounds being the cause of clouding, and some figures obtained by using Nernst's heat equation agreed very closely with the results obtained experimentally. In one experiment, pure sulphur dioxide was passed through a tube heated by a bunsen flame. No fogging occurred until the tube had cooled.

The lecturer pointed out that the cure for the defect seemed to lie in the purification of the gas used. He referred to the work of Dr. C. Carpenter, of the South Metropolitan Gas Co., who passed the gas through an iron tube containing clay balls soaked in nickel salts. The reaction that followed was represented by the equation $CS_2 3H_2 = CH_4 H_2 S$.

In the course of the discussion that followed, Mr. W. W. Warren remarked that one of the difficulties encountered in the use of the Westlake machine was the effect of sulphur in the working pot. A white splotch was produced on the glass which made the bulb unusable.

Mr. F. F. S. Bryson, Physicist to the Glass Research Association, said that that Association had also been considering the same problem, and had been in communication with Dr. Travers on the matter. He exhibited a number of lantern slides in which the effect in question was well shown. Mr. E. A. Coad-Pryor, Mr. Marden, and Prof. W. E. S. Turner also took part in the discussion of the papers.

Owing to lack of time, the last paper on the agenda, namely, "The Shrinkage, Porosity, and Density of British Fireclays after Firing at 1500°," by Edith M. Firth, B.Sc., and Prof. W. E. S. Turner, D.Sc., was postponed to another meeting.

NOTES.

Catalytic Decomposition of Chloracetic Acids.—Whereas catalysis gives cetones with acids, chlorinated cetones are not obtained with chlorinated acids.—Whether thorine, kaolin, or bone black be employed, the mixture HCl, CO, CO_2, and C, is produced with monochloracetic acid. With trichloracetic acid bone black gives, at 250° C., chloroform and CO_2, chloral did not give chloroform with CO, as might have been expected.—*Comptes Rendus*, January 17, 1921.

Cheap Manures for the Farmer.—An important arrangement which will have considerable bearing upon prices and supplies of artificial manures next season has just been completed between the Phosphate Commissioners, in conjunction with the Ministry of Agriculture, and Mr. George V. Parker, acting on behalf of the South Wales Basic Slag Company, Ltd., which is closely allied with the well-known steel firms of Messrs. Baldwins, Ltd., and Messrs. W. Gilbertson & Co, Ltd. It will be remembered that the mandate for the administration of the Island of Nauru, formerly owned by Germany, was conferred upon the British Empire, an Act of Parliament was ultimately passed by which the United Kingdom was entitled to 42 per cent of the yearly output of phosphate produced in the island. Mr. George V. Parker has acquired the whole of this allocation of 42 per cent of the output of phosphate rock from Nauru. Although the purchase price is not stated, the amount involved constitutes by far the largest transaction which has taken place in the history of the British fertiliser industry, the previous largest deal having been in Florida phosphate rock, which was purchased by the British Government during the war. It is anticipated that some 180,000 tons of high-grade phosphate rock will be shipped during each year, and the material will be delivered to various ports here, from which it will be distributed throughout the United Kingdom. By arrangements with the Ministry of Agriculture, a proportion will be sold next season as basic phosphate, at under 3s. per unit of phosphate of lime, delivered to farmers' stations. As the present quotations of phosphate of lime range from about 5s. to 7s. 6d. per unit, it would seem that the Government pledge of cheap phosphatic manures for the farmer, as the outcome of the acquisition of Nauru Island, is at long last going to be kept. The first consignments of phosphate rock from Nauru are expected to arrive in this country in June and July, and already one-third of the next six months' production has been contracted for.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

6232—Angel, H. R.—Treatment and reduction of sulphide refractory, etc., ores. Feb. 24th.
6160—Carpmael, W.—Manufacture of ethylene derivatives. Feb. 23rd.
6313—Christenson, O. L.—Production of ammonium chloride in coking or distilling coal. Feb. 24th.
6446—Christenson, O. L—Method of producing ammonium chloride. Feb. 24th.
6521—Humphries, H. B. P.—Packing, etc., material for scrubbing and absorption towers, distilling columns, etc. Feb. 26th.
6036—Imray, O.—Manufacture of mordant dyeing dye stuffs and chromium compounds thereof. Feb. 22nd.

Specifications published this Week.

158992—Kelly, A. A. and Jones, B. D.—Process for the preparation of alkali pentaborates direct from boron ores.
135854—Fleming, R.—Process for conversion of hydrocarbons into hydrocarbons of lower boiling point.
159054—Maass, O.—Process of separating aqueous and other vapours from liquids and solids for preparing dilute sulphuric acid.
159086—Sierun, S E.—Process of producing oxide of aluminium from chloride of aluminium.

Abstract Published this Week.

Separating Mercury from Amalgam.—Mr. S. H. Cocks of 6a, Ormonde Terrace, Regents Park, London, has recently obtained a Patent No. 152815 for an improved apparatus for separating mercury from amalgam, which comprises a chamber provided with a screwed air-tight cap, a perforated base secured to the chamber by clamp, a filtering medium, such as canvas, overlying the base, and a valved pipe for introducing air or water under pressure. a

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK.

Monday, April 11.

Royal Society of Arts, 8.
Royal Institution, 4. (General Meeting).

Tuesday, April 12.

Royal Institution, 3. "The Measurement of Starlight" by Prof. R. A. Sampson.

Wednesday, April 13.

Royal Society of Arts, 4.30.

Thursday, April 14.

Royal Institution, 3. "Thunderstorms," by Dr. C. T. R. Wilson.
Institute of Chemistry. (At Liverpool).
Institution of Electrical Engineers, 6.
Optical Society, 7.30,

Friday, April 15.

Royal Institution, 9. "Wolsey as War Minister," by Ernest Law.

Saturday, April 16.

Royal Institution, 3. "Poisons and Antidotes," by Dr. H. H. Dale.

G. R.

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THE CHEMICAL NEWS.
VOL. CXXII., No. 3183.

DISINTEGRATION OF ATOMS BY α-PARTICLES.

By F. H. LORING.

THE following abstract should be of interest to readers of the CHEMICAL NEWS. In a recent communication to *Nature* (March 10, 1921, cvii., 41), Rutherford and Chadwick state: It had been found that the long-range particles were charged hydrogen atoms (CHEMICAL NEWS, cxviii., 311) which indicated that some of the nitrogen atoms were disintegrated by the α-particles. Recent improvements in the optical conditions have been made, whereby the counting of the scintillations on the zinc-sulphide screen has been made easier, and the results now obtained are considered more reliable. They had been able to show definitely that the H-atoms from nitrogen have a greater range than those from hydrogen. The H-atoms driven from the hydrogen molecule or from a hydrogen compound have a maximum range of 29 cm. of air, while the H-atoms from nitrogen have a greater range of 40 cm., giving a ratio of 1 to 1·4. The range of the bombarding α-particles in these experiments was 7 cm. "This result shows that these particles cannot possibly arise from any hydrogen contamination."

Other elements were subjected to the α-particle bombardment with the result that *long-range* H-atoms were liberated from boron, sodium, fluorine, aluminium and phosphorus; but the number from boron and sodium was much fewer than from the other four elements. It had been found previously that the *long-range* H-particles were not liberated from either oxygen or carbon dioxide molecules.

With solids, the bombardment was against a thin film of the element or its oxide. Observations of the number of scintillations were made through a thickness of mica corresponding to a distance of 32 cm. of air, and the results are said to be independent of the presence of hydrogen or any hydrogen compound in the material.

The following elements were bombarded, and they showed very little, if any, effect with an absorption corresponding to 32 cm. of air:—Li, Be, C, O, Mg, Si, S, Cl, K, Ca, Ti, Mn, Fe, Cu, Sn and Au.

The gases O_2, CO_2 and SO_2 were examined for H-particles. At absorptions *less* than 32 cm. of air no traces of H-atoms were obtained. Elements other than the foregoing have not yet been examined for particles having a range less than 32 cm. in air.

The particles from all the first-mentioned elements have a maximum range of at least 40 cm. The particles from aluminium have a surprisingly long range of 80 cm.

While there is no experimental evidence of the nature of these particles, except in the case of nitrogen, it seems probable that they are all H-atoms liberated at different speeds. Assuming the law connecting the range and velocity of the H-particles to be the same as that for the α-particles, it would appear that the energy of the H-particles from aluminium is about 25 per cent greater than the energy of the incident α-particle.

Rutherford and Chadwick remark :"It is of interest to note that no effect is observed in 'pure' elements [those without isotopes, such as C, N, O and F] the atomic mass of which is given by $4n$, where n is a whole number. The effect is, however, marked in many of the elements the mass of which is given by $4n+2$ or $4n+3$. Such a result is to be anticipated if atoms of the $4n$ type are built up of stable helium nuclei and those of the $4n+a$ type of helium and hydrogen nuclei.

"It should also be mentioned that no particles have so far been observed for any element of mass greater than 31. If this proves to be general, even for α-particles of greater velocity than those of radium C, it may be an indication that the structure of the atomic nucleus undergoes some marked change at this point; for example, in the lighter atoms the hydrogen nuclei may be satellites of the main body of the nucleus, while in the heavier elements the hydrogen nuclei may form part of the interior structure"

The importance of this experimental work is of very far-reaching significance, especially in affording a powerful tool for investigating subatomic phenomena and revealing secrets which some years ago one would consider beyond the power of man to discover. The long-range particles from aluminium seem to show that we are on the track of setting free atomic energy on a larger scale than hitherto found possible.

Now that Aston has been able to isolate spectrographically some of the isotopes of the alkali metals by using a heated anode (*Nature*, March 17, 1921), we seem to be on the eve of clearing up one or two outstanding problems of chemistry and at the same time more definite knowledge of the atom itself is revealed. It would appear that lithium has isotopes of masses 6 and 7, potassium 39 and 41, rubidium 85 and 87. Sodium gives a single line answering to the atomic mass of 23. If no other mass is discovered sodium would then be known as a "pure" element.

In addition to the references given above, the following literature may be consulted: Rutherford, *Phil. Mag.*, June, 1919; *Proc. Roy. Soc.*, (Bakerian Lecture), 1920, xcvii, 374; Loring, CHEMICAL NEWS, 1920, cxx., 73, 181, 205; cxxi., 105. Aston's results in measuring the masses of isotopes are recorded in the foregoing papers by the present writer. See also CHEMICAL NEWS, 1920, cxxi., 315; cxxii., 8 (*"isotypes"* was a typographical error: it should read *"isotopes"*).

THE INSTITUTE OF PHYSICS.—The Meeting to inaugurate the Institute of Physics will take place on Wednesday, April 27, 1921, at 6 p.m., in the Hall of the Institution of Civil Engineers, Great George St., Westminster. Sir Richard Glazebrook, K.C.B., President, will preside, and Sir J. J. Thomson, O.M., will deliver an Address. Mr. A. J. Balfour is expected to be present and extend a welcome to the Institute. Non-members of the Institute or of the Societies associated with it may obtain tickets of admission on application to the

RGROWTHS ON DIAMOND.*

By J. R. SUTTON.

(Concluded from p. 162.)

ıbserved the phenomenon of the super-ı of a deep indented triangle over a ɜated spot or spot area once or, twice ıd thought that it could be explained as ncidence. The case of the above-l Bultfontein stone nevertheless makes certain that spots may on occasion in-ıe orderly rate of crystallisation, and t they are not likely to be action centres ı themselves.

ıite on the cards that a competent study ıck incrustation and the black spots may n a great deal that is yet unknown about ınd macle and so justify the use of the or the majority of macles are spotted—he composition plane—as it is not quite ' termed, seeing that the seam is not as plane at all—others in most remarkable long the grain, and yet others in both ɜther. The streaks running along the ., in the dodecahedral cleavage planes—ɔommon in macles, and practically non-ı simple crystals. Some macles display, .ving for a comparatively clear space in res, almost as much streak as diamond.

for argument, that the streaks are they show at least that macles must have a more graphitic environment than ʼstals did. It is not meant by this that ıite must have forced the macling, for :les are quite free from streaks and spots hat the two sorts of conditions were un-' which macles and simple crystals came ;, conditions perhaps in which the pro-f graphite was more favourable than it ʼhere. In this connection we may ob-: the blue grounds of the Premier and tein Mines are reported to yield a large ɜ of macles and much graphite.

within the category of coated diamonds, t in the market sense, are the occasional crystals upon whose surfaces thick coat-kind of grey bort have been deposited. might to all appearance have been put form of a wet paste, with a spatula, dried hard. Such specimens as have ght have never been completely covered rt, although there are pieces of the bort k as if they may have diamond within. ! of bort overgrowth is not commonly a natural crystal face, but rather on ɜar to be faces of arrested growth, say ɜs of attachment, and may be material ; flowed into and filled the interstices he diamonds of a cluster, at any rate it that effect. A Dutoitspan flat diamond ; found recently had such a surface of t covered with bort, and on the surface rt, which was much pitted, there were tiny black particles—whether of graph-amorphous black diamond could not be d—filling the pits. The bort over-re spoken of forms a link between com-bort and the cement-like stuff of the next section, merging by insensible gradations from the one into the other.

The Hailstone Structure.

Unequivocal proof that the crystallisation of diamond is by no means necessarily a rapid and continuous process is supplied by the diamonds which in a previous paper have been likened to hailstones ("Some Controversial Notes on the Diamond," *Trans. R.S.S.A.*, 1920, viii., 129). Such diamonds are common enough, although they do not seem to have attracted much attention. Typically they consist of what looks like a kind of hardened and more or less porous paste, superficially not unlike Portland cement, alternating with layers or shells generally of curvilinear section of clouded crystal diamond. Sometimes the core is diamond; now and then it is diamond with a small central spot of some cognate material; often it is an irregular lump of cement alone so far as one can judge of its interior without breaking it open. When the outermost layer is cement, the specimen is shapeless; when it is diamond it tends to a diamond contour—cube, octahedron, or dodecahedron—and it is usually much cracked. Naturally it is only in the broken specimens that the structure is revealed. The condition of the specimens indicates a higher co-efficient of expansion for the cement than for diamond; unless the cement is subject to secular shrinkage, which on various grounds is not altogether improbable. The colour of the cement varies from light to dark dirty-grey. It is much softer than diamond, writing a light grey streak on black amorphous bort. The denser pieces have a somewhat higher specific gravity than pure diamond; a lower specific gravity suggests porosity. Like diamond, the cement is insoluble in acids.

On account of the theoretical importance of these hailstone-like overgrowths, I venture to attempt a description of some characteristic forms. The majority are from Bultfontein.

1. A broken piece showing an irregular core of light grey cement, surrounded by a thin shell of diamond, then a thin shell of cement, the whole enclosed in a thicker shell of diamond of irregular outline. Weight 4·5 carats.

2. An irregular lump showing no trace of crystal diamond. A crater-shaped hole in a projecting corner contains a tiny fragment of bright green mineral, probably chrome diopside. 0·5 carat.

3. A broken piece with a dark grey cement interior surrounded by a confused mixture of light grey cement and diamond. 0·7 carat.

4. A flat piece showing a centre of clouded crystal diamond surrounded by an inner ring of black crystalline diamond, and an outer ring of light grey cement. The original stone, of which this is a fragment, must have been roughly spherical. 0·5 carat.

5. A flat cleavage fragment showing a hexagonal flake of clouded and spotted diamond with an outer crystalline shell of a composition apparently intermediate between diamond and cement. This specimen is of further interest as showing dodecahedral cleavage with the dodecahedral striations. 1 carat.

6. A flat cleavage fragment in plan something like the section of a pear cut parallel to the stalk. This has a crystalline core, surrounded by cement,

* Transactions of the Royal Society of South Africa.

then a thin crystalline shell, then a thicker shell of cement intersected by a portion of a very thin crystalline shell following the contour of the first for about a quarter of the way round its perimeter, and lastly, a crystalline casing. 0·2 carat.

7 A broken-off corner consisting of a black crystal interior surrounded by alternate shells of cement and diamond. Three more or less complete shells and four cement ones may be counted. 0·2 carat.

8. A flat fragment consisting of a crystal central portion surrounded by four concentric shells of about 0·5 mm. thick, two of light-coloured cement, and two of crystal. 3 carats.

9. A flat fragment broken from one end of what, to outside appearance, must once have looked like a cube of highly crystalline bort. A scraping of the broken face with a knife-blade indicates that it consists of numerous exceedingly thin successive overgrowths of bort and cement. 2 carats.

10. A somewhat hemispherical piece. The central crystal core is surrounded by no less than 17 alternate concentric rings of light grey cement and black crystal diamond. 0·4 carat.

11. A pyramid consisting of half of a "rounded octahedron." The edges, where dodecahedral striations would emerge on ordinary diamonds, are here of cement. Rather it looks like a piece of octahedral cement with projecting grey crystal bosses on the triangular faces, thus inclining the form to that of the plus and minus tetrahedral twin. 0·8 carat.

12. An irregular lump of cement to outside appearance. When first seen it was pitted with small elongated holes as though it had been prodded with the point of a pen-knife. At the time of writing it is scored over much of its surface with deep meandering cracks which either are (and look like) shrinkage cracks, or were there all the time, but hidden by being filled up with cement which afterwards fell out. 2·7 carats

13. A fragment similar to No. 10, excepting that it has rather fewer shells, has an outer coat of shiny bort, and gives the impression that the fractured face showing the shells has been glazed over with a vitreous layer and polished. The outer contour is that of the cube carrying the usual well-defined square indentations. Unlike most hailstone forms, which cleave in the dodecahedral plane, the fractured face of this specimen lies in the octahedral plane. 0·5 carat.

Mr. J. Parry has kindly analysed two small diamonds carrying this cement crust. It was not possible to separate the diamond from the cement, consequently the specimens had to be treated entire. They gave only the familiar indication for iron, and a rather stronger one for magnesia The actual proportions of these elements in the cement itself cannot, of course, be determined until a large enough sample can be procured separate. Meanwhile, it seems reasonable to infer that the comparative softness of the cement is due to the magnesia, seeing that a considerable admixture of iron with diamond (*e.g.*, stewartite) does not diminish the hardness at all.

Laminated Diamonds.

Laminated diamonds are very common. In one sense they appear to be examples of the general phenomena of overgrowths, and for that reason are included in this paper.

Suppose a model octahedron of glass to be split parallel to a pair of opposite faces into a number of thin laminæ; next the laminæ to be sealed together in their original positions by means of a transparent cement slightly harder (or slightly less solvent) than the glass; and lastly the edges of the octahedron to be abraded (or disolved) away. The layers of cement being more resistant than the glass will stand out in slight relief as the attack proceeds.

Next let the same octahedron of glass be split again into thin laminæ parallel to another pair of opposite faces and the ecmenting and abrading (or dissolving) process repeated. We shall obtain another set of layers protruding in relief and intersecting the first at a constant angle.

Finally, let the series of operations be repeated for laminæ parallel to the two other pairs of opposite faces. The whole octahedron will now be spaced out into a device of small octahedra, marking its faces with a network of flush interlacing equilateral triangles, showing in relief on the reduced edges.

Laminated diamonds are exactly like this. The laminæ are sometimes as thin as paper; more often they are in the vicinity of half-a-millimetre thick. They are not hemitropic. They alter the overall contour of a crystal very little, differing essentially in this respect from the macle, but on the other hand they modify the surface detail to some extent. The layers corresponding to the cement layers of the hypothetical glass model always protrude where they show themselves, and, as a rule, they may be easily felt with the finger-nail or with the edge of a knife. A formal analogy will be found in the octahedral structure of iron meteorites, wherein kamacite stands for the glass, and the less easily dissolved taenite for the cement.

The laminæ scarcely ever manifest their existence save on the well-developed somewhat coarsely rilled faces of the rhombic dodecahedron or tetrahexadron. On octahedron faces they are rarely seen, as also on the finely-grained rounded edges of the octahedron (which are embryo dodecahedron and tetrahexadron faces). On octahedron-dodecahedron combinations they may be traced all round a stone excepting where the octahedron faces interrupt. The intersections of the laminæ with the octahedron faces, however, are often indicated by an array of indented triangles.

In the majority of cases only one set of parallel laminæ appear on any one diamond. When two sets appear, intersecting on a solution face, one set is nearly always much more prominent than the other. An examination of a great number of laminated specimens has only determined a very few—and some of these doubtful—with more than two sets of laminæ in one stone.

In Fig. II. I have attempted to depict a laminated octahedron-dodecahedron combination from Wesselton, showing two sets of laminæ. It is one of the rare cases in which the edges visibly cut the octahedron face. Though some relationship between the laminæ and the indented triangles is shown, it is not so marked as in many other specimens, wherein, while the edges themselves are not visible, their course is traced out by rows of little triangles, all much of a size, in a row.

On the rotating stage under the microscope, the edges of the laminæ give a singularly pleasing effect. They prove them to be more of the nature of steps down facing away from the shorter diagonals of the rhombic faces, than of definite protrusions; and their undeviating straightness, so different from the vacillating composition plane of the macle, contrasts sharply with the rippled surfaces they cut.

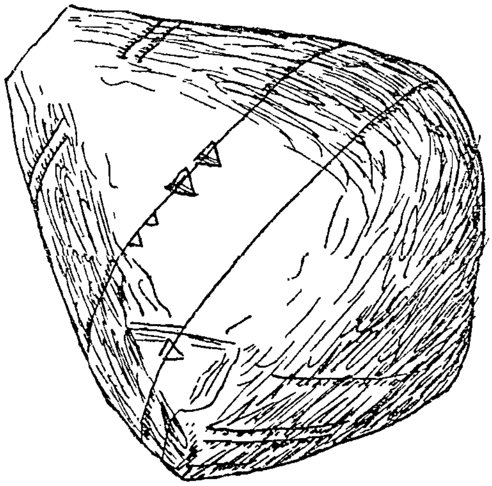

FIG. II.—Laminated Wesselton Diamond, enlarged.

Geometrically, the shorter diagonal of a rhomb of a dodecahedron coincides with an edge of the derived tetrahexahedron. The same rule is approximately true for such diamonds as are of good symmetry, and are not laminated; but when diamonds are laminated the rule is varied, in that the tetrahexahedron edge tends to slant away from its geometrical position into parallelism with the edges of the laminæ. This is, perhaps, the most important change made by the lamination on the aspect of a stone.

Fersmann and Goldschmidt have described ("Der Diamant," 1911) three laminated diamonds, all Brazilian, namely: Crystal No. 26, an irregular lump of a weak violet colour, showing lamination in three directions; Crystal 32, a brownish regular dodecahedron, whose surface is covered by a delicate network formed of innumerable twin lamellæ in four sets; and Crystal 33, a brown dodecahedron with coarse lamination. They argue that most diamonds may be presumed to be composed of such lamellæ, and that the lamination is brought into view by the process of solution. They seem further to hold that hemitropic twinning is the cause of the phenomenon. It is curious that their drawings of crystals 32 and 33 show the protruding edges of the lamellæ as running nearly parallel with the edges of the rhombs, a feature not actually possible in nature. Indeed, in this respect their version of the aspect of 33 differs absolutely from that of Rose and Sadebeck, made some 40 years earlier, and which they reproduce for comparison with their own.

Boutan also regards these laminated diamonds as macles by hemitrophy. He further regards Brewster's celebrated lens of diamond as having been cut from a multiple twin of this kind—a remote possibility, maybe, though not quite a probability, if only for the reason that a laminated stone is not likely to be transparent enough to serve as a good lens.

One reason against hemitrophy is that one sometimes comes across laminated stones which could just as well be called in the French way "macles by penetration," *i.e.*, tending to conform geometrically to the interpenetrating twins of the plus and minus tetrahedra; the lamination giving a terraced aspect to the blunt protruding pyramidal bosses very like the terraced diamonds from Jagersfontein in miniature. Another reason is that lamination is limited to four definite directions each of which is parallel to an octahedron face, so that in any laminated stone each multiple twin set intersects another at a constant angle; and this is the case even when the specimen is a macle. But macles when they intersect one another are not limited to definite directions at all; their seams crossing almost at random much as irregularly twinned simple crystals interpenetrate.

Lamination has an intimate correlation with colour. With very few exceptions, all laminated diamonds, no matter where they come from, are coloured—brown, mauve, green, or blue-white. Slight lamination may also be seen once in a way on poor cape-white diamonds, and on poor yellow ones. Reflexively, nearly every brown, and nearly every mauve, dodecahedral diamond, either macle or simple crystal, whether the tint be light or dark, is plainly laminated. (The featureless brown diamonds of resinous lustre from South-West Africa do not show lamination so often as brown diamonds from other sources. For that matter South-West African diamonds seldom show any surface detail at all to speak of, saving either an exceedingly high polish or a roughening due perhaps to wind erosion). So are most blue-whites when they are of a milky transparency or when their tint inclines to mauve. Lamination also occurs among the green diamonds from the Rand banket.

Hitherto I have only succeeded once in seeing signs of lamination in the interior of a diamond. This was in an ugly dark-brown brilliant in which the lamellæ were marked out in alternating lighter and darker brown streaks. A fair inference seems to be that a diamond going in general through stages of growth and quiescence may, during the latter, become covered with colouring matter which is enclosed in a later growth. The apparent uniform tint of the final whole stone will be largely a refraction effect (like the grey colour imparted to coated stones by indefinitely thin layers of tiny black spots), and is the happier as the laminæ are thinner. Thus the colouring matter is an overgrowth which establishes the lamination. There is no doubt that Heddle when he alleged the disseveration of "plate diamonds" ("Ency. Brit.," 9th Ed., Art. "Mineralogy"), was confounding the mythical bursting of smoky stones with the lamination of brown ones.

(*Addendum.*—While the above paper was going through the press I had the good fortune to see a most important specimen of diamond embedded in calcite, found by Mr. J. T. Vigne in the working over of some old Kimberley lumps. The diamond appears to be of about four carats, and the enclosing calcite perhaps five carats. The dia-

mond has evidently not been squeezed into the calcite, but has acted as a nucleus upon which the latter has crystallised. Mr. J. Stewart has, also, given me a portion of a beautiful shell of calcite taken from a Wesselton blue-ground diamond. The interior faces of this shell have acquired, from their intimate contact with the diamond, an almost perfect adamantine lustre).

FURTHER STUDIES CONCERNING GALLIUM.

ITS ELECTROLYTIC BEHAVIOUR, PURIFICATION, MELTING POINT, DENSITY, COEFFICIENT OF EXPANSION, COMPRESSIBILITY, SURFACE TENSION, AND LATENT HEAT OF FUSION.*

By THEODORE W. RICHARDS and SYLVESTER BOYER.

I. *Electrolytic Behaviour.*

INTRODUCTION.—The study of the electrolytic behaviour of gallium naturally had precedence in this investigation, because this behaviour had an important bearing on the preparation of the material needed for the rest of the work. The earlier experimenters upon gallium commonly used electrolysis rather as a means of precipitating the metal from purified salts than as a means of purification. In a recent paper, Dennis and Bridgman have pointed out the value of electrolysis for the latter purpose (Dennis and Bridgman, *Jour. Amer. Chem. Soc.*, 1918, xl., 1540; on p. 1537 references to earlier work are given). Independently, we also had simultaneously thus used electrolysis (Richards and Boyer, *ibid.*, 1919, xli., 133). Whereas the earlier experimenters commonly used alkaline solutions, Dennis and Bridgman, as well as ourselves, worked with more or less acid ones, free from alkali salts, thus eliminating the danger of contamination with alkali metals.

Although in the main the verdicts of the recent researches agree, several obscure points need elucidation before the matter is entirely consistent and comprehensible. The points especially to be investigated were the following: first, the single electrode potential of gallium, and secondly, the order of precipitation of indium, zinc, and gallium, with several different current densities from solutions of several different acidities.

The Single Electrode Potential of Gallium.—No adequate measurements of this potential appear in the literature, but the element is usually considered as coming between zinc (0·52) and aluminium (1·0), being nearer to that of zinc (see for example, Abeg's "Handbuch der anorg. Chem.," 1906, iii., [1], p. 367; *Compt. Rend.*, 1875, lxxxi., 493). This conclusion is based upon the earlier work of Lecoq and Boisbaudran.

For our measurements an accurate potentiometer, standardised by means of a Weston cell, was used. Cadmium and zinc were also measured against a calomel electrode in order to be certain that the apparatus was functioning properly. The single potential difference of cadmium in normal solution of its sulphate was found to be 0·176, and that of zinc in normal solution of its sulphate, 0·521. Hence the apparatus was adequate. Care was taken, in many of the trials, to have solutions of gallium sulphate neither basic nor with excess of acid, by converting weighed amounts of gallium (through the nitrate and weighed amounts of sulphuric acid) into sulphate. These precautions were, however, probably not necessary, because a small concentration of free acid does not usually much affect a single electrode potential. With amalgamated zinc, for example, 3 N sulphuric acid was found by rough measurements to affect the potential by less than 0·05 volt. The potential of the decinormal electrode was assumed to be +0·56 volt. No allowance was made for the unknown solution-solution e. m. f.

In every case gallium showed at first a much smaller negative potential than the final value. With metal which had been exposed for a long time to the air the initial value was even positive (as much as 0·2 volt). In the course of two or three days the gallium potential gradually attained the maximum value —0·297 in 0·1 N solutions; somewhat less (—0·25) in N solutions, and even less when excess of sulphuric acid was present. 0·1 N gallium alum as electrolyte gave about the same potential (—0·294 volt) as pure 0·1 N gallium sulphate.

Adequate comparison of the effects of ion concentration, corresponding to the Nernst equation, can hardly be made, because the ion-concentration of gallium sulphate has never been determined. The substance is much hydrolysed, and probably hydrolysis diminishes the concentration of the gallium ion in dilute solution, making a colloidal hydroxide.

Liquid gallium *decreased* in potential with the time of immersion, to a lower value (—0·18) than the solid. Resolidification reversed this effect, but the gallium thus liquefied never assumed the value it would have had if its potential had been first determined as a crystalline solid. The decrease was hardly consistent enough to substantiate Rudorf's conclusions (Rudorf, Abegg's "Handbuch," *loc. cit.*, p. 366) concerning the free energy of the liquid based on Regnauld's measurements (J. Regnauld, *Compt. Rend.*, 1878, lxxxvi., 1457 (not Regnault, as Abegg gives the name).

Whichever final value is chosen from the above-mentioned results, the single electrode potential of gallium thus measured stands between that of indium (—0·10) and that of zinc (—0·52). This was one reason for the statement to that effect in our earlier paper, because preliminary measurements of the electrode potential had been made before that paper was published. It will be seen, however, that this outcome gives an incomplete picture of the situation.

Another method of attacking qualitatively the problem of relative electrode-potential is by placing one metal in the solution of the salt of another, in order to determine if the second metal is precipitated at the expense of the first. De Boisbaudron's description of his result in this direction is not easily interpreted, but the simple experiment seemed worth repeating. Accordingly small amounts of fresh electrolytically precipitated zinc were placed in two portions of 5 cc. each of N gallium-sulphate solution. After 15 hours, most of the gallium was precipitated in the form of a voluminous semigelatinous, white basic precipitate. In one case the slight metallic residue (after thorough washing, and the solution of

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the zinc in very dilute acid), gave spectroscopic evidence of gallium—but the amount was only a very small fraction of the whole, and may have been due to inclusion. Evidently zinc does not precipitate metallic gallium in the definite fashion in which, for example, it precipitates cadmium.

The contrasting experiment of placing gallium in a nearly neutral zinc-sulphate solution was likewise made. After standing for 24 hours, the nugget of gallium showed no sign of a "tree," even in the microscope, and its surface appeared almost, if not quite, as bright as at first. Evidently gallium does not precipitate zinc.

When a solid alloy of gallium and zinc is treated with a little diluted sulphuric acid, both zinc and gallium are dissolved until the acid is exhausted, and no "tree" of either metal forms on the etched and pitted button.

These qualitative experiments leave one still largely at a loss with regard to the electrode potential of gallium. They seem to indicate that this quantity may be nearly the same as that of zinc.

A clue to the answer to the puzzle was afforded by the following experiments. Small fragments of the purest gallium, freshly cut, were placed in solutions of cadmium sulphate and of copper sulphate. Neither fragment showed more than a very slight tendency to precipitate these metals, each of which (especially copper), must have a lower solution tension than gallium. After six hours no evidence of precipitation at all was manifest, and even after several days, only a few minute spots of copper could be seen. (Afterward, following a suggestion by A. B. Lamb, copper chloride was tried. Here also the precipitation of copper was very slow in starting, but when once started it proceeded more rapidly with the chloride than with the sulphate). Clearly gallium, like its analogue aluminium (see for example v. Deventer and v. Lumnel, *Z. physik. Chem.*, 1909, lxix., 136), has a distinct tendency to become passive (or "ennobled"), which must vitiate all attempts to determine its true active electrode potential by the methods heretofore recounted. Accordingly, another line of attack was begun.

The Electrolytic Precipitation of Gallium, Indium, and Zinc from Solutions of Varying Acidity and Concentration.—The outcome of electrolytic precipitation depends, at least in part, of course, upon the electrode potentials of the substances concerned; but it depends also on at least three other conditions of electrolysis, namely, on the relative concentrations of the ions, on the current density at the cathode, and on "over-voltage" phenomena.

The effect of the concentration on the cation, as expressed by the Nernst equation, is well known. The solution tension of the solid metal is assumed to remain constant, but the effect of the opposing osmotic pressure of the cation increases with its logarithm; hence the single electrode potential decreases when the cation becomes more concentrated. For a trivalent ion such as indium or gallium, the theoretical increase in electromotive force is about 0·02 volt for each tenfold dilution at room temperatures. In order to change the electrode potential by as much as 0·1 volt, the solution must obviously be diluted to at least one hundred thousand times its original volume (or possess a concentration of 0·00001 of not play a very important rôle in causing two metals 0·2 or 0·3 volt apart in the electrochemical series to appear together.

As an example of the combined effect of changing current density and "over-voltage," the following fact may be cited. Zinc, although commonly possessing a far greater solution potential than hydrogen, can be precipitated in part from normal solution of the sulphate in the presence of $2N$ sulphuric acid by a current density of 0·4 amp./cm^2., whereas this precipitate will redissolve while the current is running if the current density is reduced to 0·2 amp./cm^2. In brief, there is a fairly definite relation between the current density, the concentration of the acid and the concentration of the metal which remains in solution after long-continued electrolysis. These considerations are of importance in interpreting the separation of metals electrolytically, especially if conclusions concerning relative electrode-potentials are sought.

The following experiments upon the electrolytic deposition of gallium, indium, and zinc, separately and together, were comprehensive, but will be summarised as briefly as possible. In all of these experiments sulphuric acid was present in definite, but not always identical, excess over the amount corresponding to the bases present. As the electrolysis proceeded, sodium hydroxide was added in amounts needed to neutralise the acid formed and keep the hydrogen-ion concentration about constant. The nature of the electrolytic precipitate was determined partly by its melting point, but usually by spectrum analysis. The three metals chiefly concerned (gallium, indium, and zinc) give clear spark- and arc- spectra, alone or together; our experience agrees with that of Dennis and Bridgman in showing that very small traces of each metal may be detected in the presence of the others. The characteristic lines, being in the blue and violet, are all easily photographed. Our comparisons were made almost entirely in this way with a good glass-prism spectrometer. The metals were volatilised by an arc spark obtained from a half kilowatt transformer from the 110 volt, 60 cycle, alternating current of the laboratory. The spark was intensified by a suitable condenser in parallel with the transformer, and the air lines were cut out by adequate inductance. Platinum points about 2 mm. in diameter were used as terminals of the spark gap, and the metals to be analysed were precipitated electrolytically directly upon the terminals, although these were not the electrodes of the fractional precipitation. Blank tests were frequent.

To recount first experiments upon the metals taken separately:—

Comparable results were obtained with platinum foil electrodes of 8 sq. cm. area and 0·3 ampere current (that is, an approximate current density of 0·04 amp. per sq. cm.). The volume of the solution in each case was about 100 cc. or less, and during the electrolysis each was continuously and thoroughly stirred by a mechanical stirrer. The amounts of indium, zinc, and gallium originally present were respectively about 0·4g., 0·2 g., and 0·1 g. The precipitated metal was completely transferred electrolytically from time to time to the spark gap terminals. With solutions of 0·2 N acidity, about 0·6 mg. of indium remained per

times as much zinc and almost all the gallium present. Electrolysed in solutions of 0·1 *N* acidity, all the indium was precipitated in 16 hours, about 1·2 mg. of zinc remained per 100 cc. solution after similar treatment, and distinctly more (90 mg. per 100 cc.) of the gallium. Zinc in a new trial was very nearly all precipitated in eight hours from a solution of 0·05 *N* acidity, whereas 0·025 g. of gallium remained per 100 cc. of such solution after 13 hours. In a fourth trial after 17 hours even from a 0·04 *N* acid solution, gallium was not fully precipitated, one mg. remaining per 100 cc. of electrolyte.

The results with more concentrated acid pointed in the same direction and need not be recounted in detail. No metal at all was precipitated by this low current density from a solution containing 0·4 g. per 100 cc. and 1·7 *N* in sulphuric acid; very little indium, less zinc and no gallium from such a solution normal in sulphuric acid; and nearly all the indium, most of the zinc, and very little gallium even from a solution 0·5 *N* in sulphuric acid.

These results are all consistent; they point indubitably to the following order of precipitation: indium, zinc, gallium, and indicate that, whatever the cause, gallium has a considerably higher deposition-potential than zinc in these acid solutions. But this result is inconsistent with the direct potential—measurements already recounted—for these placed gallium between indium and zinc.

Turning now to the electrolysis of mixtures, the following methods were used and results obtained. The volume was in each case about 0·5 litre; the same current density as before (namely, 0·04 amperes per square cm.) was maintained; and the acidity was initially 0·15 *N*. When precipitation was almost finished, the acidity was reduced in order to recover all of the gallium. Six successive electrolyses of mixtures were conducted. In every case zinc was detected in the first precipitate (which was chiefly indium) and it was found at every stage of the electrolysis, successive portions of the precipitate being taken out and examined spectroscopically. Evidently indium and zinc are too near together to allow easy electrolytic separation, although theoretically their electromotive ranges should not seriously overlap; and the same is true of gallium and zinc. But in every case gallium began gradually to appear only after most of the indium had been precipitated. Hence these two metals are far enough apart to be easily separated.

Similar results were obtained with platinum points giving much greater current density, in strongly acid solutions. When a platinum point is used for deposition instead of a foil, the current density is so great that the ionised hydrogen in the immediate vicinity of the electrode is not enough to carry the current even when the solution is strongly acid. Hence other cations of greater solution potential may come down with the hydrogen. By preference, of course, those with smallest negative solution potential come out first. Thus, with a platinum point in 5*N* sulphuric acid, we found that almost pure indium with melting point 155° came first out of a mixture of the three metals under consideration, if sufficient current density were used to precipitate anything besides hydrogen.

When only a small amount of zinc was present in the electrolysis conducted in this way, most of it appeared in the final deposit obtained after neutralising the free acid. This fact is in accord with the results obtained with zinc alone, in which it was shown that this metal cannot be precipitated completely by current density 0·04 from a solution 0·1 *N* in acid.

Thus there is no real inconsistency between our results and those of Dennis and Bridgman. Different conditions produced different results. The amount of zinc in the specimen involved in our early trials was so small that little of it could be deposited by the current density and with the acidity then employed. Hence, most of the zinc remained in the electrolyte to the end and the order of deposition in this case was gallium, indium, zinc, as stated. The fact that most of the zinc was deposited in the early part of the electrolysis of Dennis and Bridgman is easily explained if their solution (as is probable from their description) was decidedly less strongly acid than ours.

The explanation of the apparent inconsistency between the relative magnitude of the electrode-potentials and the order of actual deposition seems to indicate that gallium possesses a larger negative electrode-potential in the act of depositing from a solution than it possesses when actually deposited. In other words, it probably possesses some degree of "passivity" when in a metallic state, as already indicated by other tests. This conclusion is supported by the fact that gallium is markedly passive toward dilute nitric acid, although it dissolves in concentrated nitric acid It seems to occupy a place, in this respect, between indium, which dissolves easily in nitric acid of any concentration, on the one hand, and aluminium, which is passive towards dilute sulphuric and concentrated nitric acid, on the other hand. Our experiments on electrode-potential indicated that liquid gallium is even more passive than the solid. This agrees with the fact that liquid gallium is less easily attacked by acids than solid gallium, although this fact may be due, as Rudorf has pointed out (Rudorf, Abegg's "Handbuch," *loc. cit.*), merely to the possession of more points of attack in the solid. All these questions will receive more detailed examination here in the near future. An answer to the vexed question as to the cause of passivity in general, or of this case in particular, is left in abeyance for the present.

II. Purification of Gallium.

The foregoing statements make clear the advantage of electrolysis as a first step in purification. The elimination of indium and all metals of lower solution tension is easy by this means. Accordingly this method was used as an initial step in the purification of the large quantity of gallium needed later for determining the properties of this substance.

The choice of electrodes for electrolysis was made with care. The liquid metal alloys with silver, making it brittle; and the deposited gallium contains dissolved silver. Hence this metal is entirely unsuitable. Iron seems to show in less degree a similar effect, except that the solid alloy is soft instead of being brittle. Gallium alloys slightly even with platinum foil, which is blackened afterwards by acid. Moreover, the

liquid gallium removed from this platinum foil may contain traces of platinum.

A point of wire is evidently safer than a large piece of foil, since the action of one metal upon the other can take place only on the surfaces where they adjoin. Thus gallium from an iron point was found to contain no appreciable iron. That from a platinum point is even safer, since platinum is attacked less than iron is. Finally, in preparing our purest material we used as the electrode a gallium cathode contained in a cup and making contact beneath its surface with a platinum point of minimum dimensions.

During the electrolysis of a solution of the raw material (a crude gallium indium alloy) the hydrogen evolved was found to give a mirror in the Berzelius-Marsh apparatus. Part of this sublimate was shown to be arsenic, and germanium was indicated by the line 4033, although the two more prominent lines, 4227 and 4180, were often absent. A line very close to 4058 was likewise found. This was most probably due to lead, although this metal does not ordinarily form a volatile compound with hydrogen on electrolysis. It is true that Panett and Fürth (Panett and Fürth, *Ber.*, 1919, lii., 2020) state that they have found such a compound (the particulars to be given later) but we have not been able to reproduce it. Whether the apparent presence of lead and also trace of zinc in the Marsh-Berzelius mirror were due merely to the spattering (which, however, had been carefully guarded against) or to traces of volatile compounds we do not pretend to decide. That arsenic was present there could be no doubt. The spectrum was compared with the spectrum of pure arsenic in a Plücker tube at 220° to 230°, taking the helpful precautions of Herpertz (Herpertz, *Dissertation*, Bonn, 1906). The suitable vacuum was obtained by a Langmuir pump.

Incidentally, mention may be made of a black precipitate consisting chiefly of gallium, and of a spongy aggregation which appears at the cathode under some conditions, the latter especially when the solution is almost neutral. It was easy to prove that both consisted of metallic gallium mixed with a trace of basic salt and bubbles of hydrogen which prevent its complete coherence.

Gallium deposited from the solution of the crude liquid alloy, when most of the indium had been separated electrolytically, contained considerable zinc. This could be, in part, eliminated by fractional electrolysis, but the process is slow, as may be inferred from the foregoing account.

Two methods were therefore employed which were found to be effectual in removing the last trace of this metal, namely, ignition at a red heat in a vacuum (when zinc distils by virtue of its lower boiling point) and fractional crystallisation of the gallium with centrifugal draining (when all heteromorphous materials remain in the liquid).

The purification by heating in vacuum is most conveniently carried out by placing the electrolytic metal in a silica boat enclosed in a silica tube, and heating for several hours in a good vacuum until the boat-load remains almost constant in weight. Complete constancy is not attained, since gallium itself is slightly volatile at 800°. The sublimate was shown by suitable qualitative tests to consist chiefly of zinc. The residue from this treatment must still have contained a trace of some unknown impurity since its melting point was still not quite constant.

Fractional crystallisation of the metal was the method used to complete the purification. Liquid gallium, supercooled to a temperature slightly below its true freezing point, was inoculated with a trace of the solid phase, introduced on a platinum point. Crystals of gallium 4 to 6 mm. in length were allowed to form slowly. Consisting of the purer gallium, these crystals were removed, but upon their surface they carried some of the less pure liquid. This was removed by means of a hand centrifuge, the inner vessel of which consisted essentially of a test-tube with a much constricted place near the bottom. The crystals of gallium rested upon the constriction, and the liquid was driven by centrifugal force through the narrow opening, while the test-tube, resting upon a pad of cotton wool in a hollow wooden cylinder attached to a stout leather strap, was whirled in a two-metre circle. Before the slightly warm glass vessel was placed in the wooden receptacle, the latter had been warmed to 32° in order to prevent solidification of the adhering liquid before the centrifuging was complete. Two or three successive recrystallisations were enough to bring the purest fraction to a constant melting point, but in order to economise the small amount of fairly pure electrolytic material at our disposal as much as possible, many systematic recrystallisations from the mother liquors were conducted, thus purifying more of the gallium.

In all 10·4 g. of pure gallium of constant melting point (that is, showing no change in melting point from the beginning to the end of liquefaction) was separated from about 15g. of the less pure electrolytic metal. This specimen was called Sample E.

III. The Melting Point of Gallium.

De Boisbaudran, in successive trials, at first found the melting point of gallium to be 29·5°, and later 30·15°, with very small amounts of material (*Compt. Rend.*, 1876, lxxxii., 1036; 1876, lxxxiii., 611). More recently, Browning and Uhler found the value 29·7° by reading the temperature at which globules of solid gallium fell through a slightly smaller platinum ring (*Am. J. Sci.*, 1916, [4] xlii., 389). Neither experimenter mentions the precautions taken with regard to standardising the thermometers; and judging from our experience, probably neither had perfectly pure gallium.

Our own preliminary experiments, made by watching a crystal of the metal (either at the bottom of a small test-tube or suspended in a ring immersed beneath a slowly changing bath) usually gave too high results because of convection currents, and the lag in temperature of the metal. Methods of this sort led to the value 30·8° (which we found subsequently to be about a degree too high) for the melting point of our best gallium. An accurate determination of a melting point can hardly be made unless enough of the substance is at hand wholly to surround the registering instrument with a mixture of the two phases whose equilibrium is concerned. Therefore we did not succeed in obtaining satisfactory values until we used a much larger quantity of the metal.

Two methods were finally employed. First, the gallium was melted in a small air-jacketed test-tube in an easily adjustable thermostat, after the fashion of the Beckmann freezing-point apparatus, or that so often used by one of us for taking transition temperatures (see for example, Richards and Wells, *Proc. Am. Acad.*, 1902, xxxviii., 431; *Z. physik. Chem.*, 1903, xliii., 465). In this apparatus about 10 g. of the best gallium was used. Its melting point remained constant until only a very few crystals remained.

Another method which gave precisely the same result consisted in determining the temperature at which a glass-stoppered dilatometer, filled with a mixture of crystallised and liquid gallium under water, showed neither decrease nor increase in the volume of its contents with time. About 8·5 g. of crystallised gallium was used. The water was pure and was freshly boiled and quickly cooled; so prepared it does not oxidise gallium seriously in a few hours. The scale on the capillary of the dilatometer showed change of about 0·4 mm. during the melting of 0·01 g. of gallium. The dilatometer was immersed to the beginning of the index tube in a thermostat at 29°, and the temperature was slowly raised until melting was indicated by the sinking of the water level in the capillary. After perhaps a quarter of the metal had melted, the temperature was slowly lowered until the column remained stationary.

The small thermometer used with each method was very carefully standardised with reference to the Parisian hydrogen scale through one of the Harvard Baudin thermometers, both being read with a cathetometer to within 0·002°.

The direct determination of the melting-point in the small Beckmann apparatus gave the value 29·752° for the melting point. With the dilatometer method, at 29·755°, the column slowly descended, whereas at 29·745 it slowly rose, indicating the value 29·75° as the true melting point. Since the two methods agreed, this value (29·75°) may be taken as correct for the purest gallium which we have thus far prepared.

IV. Density of Solid and Liquid Gallium.

The striking expansion of gallium upon solidifying is of peculiar interest, since this property is possessed by so few substances. Some previous investigators have ascribed it to the presence of impurities (Rudorf, Abegg's "Handbuch," *loc. cit.*). The work which follows shows, however, that undoubtedly the purest gallium behaves in the same way as the somewhat impure metal first studied.

The form of pycnometer employed was that used recently in the determination of the density of lead isotopes (Richards and Wadsworth, *Journ. Am. Chem. Soc.*, 1916, xxxviii., 222). All the usual precautions were taken to ensure constancy and definiteness of temperature, absence of air bubbles (the pycnometer was filled in a vacuum) and protection from evaporation. Both the solid and liquid gallium were weighed under freshly boiled and quickly cooled pure water. Without precautions, gallium, on solidifying in a pycnometer invariably breaks it by the expansion which then occurs; but if the pycnometer is constantly agitated during slow cooling the crystalline mass does not attach itself to the vessel, nor subject the walls to outward pressure. If solidification against the walls begins to take place, it is easily overcome by partial melting and resolidification. When the density of the liquid was determined after that of the solid, the pycnometer was placed in an evacuated vessel in order to remove any trace of hydrogen which might have been formed by the long standing under water. Promptness is advisable since even with the purest water a slight action takes place after a number of hours, and, of course, both bubbles of gas and the film of oxide cause a decrease in the observed density of the metal.

The densities of a number of samples were determined. The first sample, A, contained several per cent of indium and a trace of zinc. It was obtained from the hydroxide dissolved in sodium hydroxide, which carries with it indium hydroxide. From Sample B most of the indium had been removed by fractional electrolysis. Sample C had been refractionated electrolytically from a solution 2 *N* in free sulphuric acid and the metal had been heated in a vacuum for three hours to expel zinc. Sample C_2 was another preparation of the same kind. Neither was entirely free from impurities. Therefore Sample D was prepared with much greater care by fractional electrolysis, but it began to melt on the surface 0·2° below the true melting point of gallium. Sample E, the purest, has already been described above.

(To be continued.)

THE CHEMICAL INDUSTRY IN THE ARGENTINE REPUBLIC.

THREE Argentine companies manufacture sulphuric acid (53°-56° Baumé) by the chamber process with imported sulphur from Italy, Chile, and the United States. There is a great demand for Sicilian sulphur, since, being of greater purity, and burning without ash. Transport of sulphuric acid by sea is very difficult, owing to long voyages in the tropics, the home industry being thus favoured. Nevertheless, local works find it difficult to compete with imports.

Nitric and hydrochloric acids, the first in commercial degrees (38° and 42°), are manufactured from Chile saltpetre and native salt. Chemically pure sulphuric and hydrochloric acids are, however, manufactured. The main part of the acetic acid imported is glacial, at 99°. Two works near Cordoba produce pyroligneous products by dry distillation of algarrobo wood, chiefly acetates of lead and lime acetone, acetic acid, which are more expensive than imports. However, the demand exceeds the supply. Local production of tartaric acid is limited to one or two vineyards, wine lees being obtained in large quantity at Mendoza. In 1916 the United States began to export this acid to the Argentine. During the last eight years, imports of citric acid from France, England, Germany, and Italy, represented an average of 132 metric tons per year. The United States commenced exports in 1914. The acids sell better in crystals than powder. Imports of phenic acid are very irregular; England is the chief manufacturer. Tar oil acids are preferred to wash cattle

The oils should contain at least 10 per cent phenol, and some manufacturers say 25 per cent. Boric, carbonic, hydrofluoric, and tannic acids are also imported from Germany, France, England, and, since 1916, the United States has supplied a certain amount of carbonic acid. Gaseous carbonic acid is manufactured locally in breweries. Imports of alum, which were more than 6300 metric tons from 1913 to 1916, fell to 490 tons during the last two years. The United States imports now represent 50 per cent. Hydrated alumina is employed to a limited degree for lakes and colours, textiles and glass. Large quantities of home-made sulphate of aluminium are employed to purify drinking water in Buenos Ayres, &c. Local manufacture is only one-quarter of the imports. Ammonia is chiefly imported. The average imports during the last seven years were 540 metric tons per year, 90 per cent being from America. Liquid ammonia is chiefly English. Arsenic and arsenical compounds are employed for glass, insecticides, and colours. The demand is for white, yellow, and red arsenic (99 per cent), in barrels of 200 kilogrms., and arseniates of lead and soda in boxes of 5 kilogrms. The United States now heads the list of imports.—*Chimie et Industrie*, February, 1921.

PROCEEDINGS OF SOCIETIES.

MINERALOGICAL SOCIETY.

March 22, 1921.

Dr. A. E. H. Tutton, F.R.S., in the Chair.

The following papers were read:—

"*The Vibrations of a Crystalline Medium.*" By Prof. H. Hilton.

The paper attempts to give an indication of the kind of vibrations which the molecules of a crystal may be expected to make about their positions of equilibrium. The case of an orthorhombic crystal in the form of a rectangular parallelepiped is considered in detail, and the normal modes of the molecular motion completely determined.

"*Augite from Nishigatake, Japan.*" By Prof. R. Qhashi.

The crystals have been detached from basalt by natural weathering. Specific gravity is 3·338 at 4° C. The prism angle agrees with that of diopside, but that of the pyramid does not. Etched figures show that the crystal belongs to the holosymmetric class $\alpha=1{\cdot}6859$, $\beta=1{\cdot}6917$, $\gamma=1{\cdot}7105$, $2v=58°\ 25'$. Extinction angle on $(010)=41{\cdot}6°$. The chemical composition is SiO_2 51·37, Al_2O_3 5·24, Fe_2O_3 2·02, FeO 2·96, CaO 21·58, MgO 16·94, TiO_2 0·58. Both the optical properties and chemical composition show that in this augite the diopside molecule predominates.

"*The Chemical Composition of the Adare and Ensisheim Meteorites.*" By Dr. G. T. Prior.

Determination of the amount and composition of the nickeliferous iron in these meteorites had shown that Adare contained 18 per cent, in which Fe : Ni=11, and Ensisheim 3 in which Fe : Ni=3½. Analyses were made of the unattracted material in order to determine how far they supported the idea that in meteoric stones the ratio of MgO to FeO in the magnesium silicates varied directly with the ratio of Fe to Ni in the nickel-iron. The results showed that the ratios of MgO to FeO in the olivine and pyroxene respectively were about 4 or 5 for Adare, and 2½ and 3 for Ensisheim.

Mr. W. Barlow exhibited models to represent the atomic structure of calcite and arragonite.

NOTES.

Royal Society.—At the Meeting of June 2, the Bakerian Lecture will be delivered by Dr. T. M. Lowry, F.R.S., and Dr. P. C. Austin, on "Optical Rotatory Dispersion."

Royal Institution.—A General Meeting of the Members was held on April 4, Sir James Reid, Bart., Vice-President, in the Chair. Mr. S. D. Bles, Mr. S. T. Covington, Mrs. L. W. Dent, Mr. B. G. Donne, Prof. Godfrey, Com. A. C. Goolden, Mr. A. Mallalieu, Mr. W. Marshall, Mr. E. W. T. L. Brewer Williams, and Sir John Wormald. were elected Members. The Chairman reported the death of Lord Moulton, a Member of the Institution, and a resolution of condolence with the relatives was passed.

Royal Institution.—On Tuesday next, April 19, at 3 o'clock, Prof. Arthur Keith resumes his Lectures at the Royal Institution on "Darwin's Theory of Man's Origin (In the Light of Present-Day Evidence)"; on Thursday, April 21, Mr. H. S. Foxwell begins a course of two lectures on "Nationalisation and Bureaucracy"; and on April 23, Mr. H. Y. Oldham delivers the first of two lectures on the "Great Epoch of Exploration: (1) Portugal; (2) Spain." The Friday evening Discourse on April 22 will be delivered by Sir James Walker on "Electro-Synthesis in Organic Chemistry," and on April 29 by Sir Frank Dyson on "Advances in Astronomy."

Market for Ant Exterminators in Colombia. —The Commercial Secretary to H.M. Legation at Bogota (Lt.-Col. G. W. Rhys Jenkins) reports that there is an urgent demand in the Santa Marta district for a good ant exterminator for use on the local coffee plantations. It appears that practically all the estates are infested with quantities of large brown ants, which devour everything in sight, including the young coffee shrubs. The Commercial Secretary has received an enquiry as to United Kingdom sources of supply of a suitable exterminator, and particulars will be furnished to any United Kingdom firms interested, on application to the Department of Overseas Trade (Development and Intelligence), 35, Old Queen Street, London, S.W.1.

The Automatic Furnaces, Ltd., have issued a small pamphlet presenting some carefully arranged data on the effects of overheating high carbon steel. The Company have for years specialised in precision heat treatment of steel, and now are undertaking to harden samples of manufacturers' own tools for a comparative test against similar articles hardened by the maker. The pamphlet in question and full information can be obtained at the Company's offices, 281-283, Grays Inn Road, W.C.1.

AT the recent Guthrie Lecture at the Physical Society, Prof. A. A. Michelson, of the University of Chicago, took as his subject "Some Recent Applications of Interference Methods," and gave details of his recent work on the Measurement of Earth Tides, A Redetermination of the Velocity of Light, and the Measurement of the Diameters of Fixed Stars.

IRON AND STEEL INSTITUTE.—The Annual Meeting of the Institute will be held, by kind permission, at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, May 5 and 6, 1921, commencing each day at 10 a.m. Thursday, May 5—General Meeting of Members; a selection of Papers will be read and discussed. Friday, May 6—Annual General Meeting. The following is a list of the Papers which it is expected will be submitted :—

"The Prevention of Hardening Cracks, and the Effect of Controlling the Recalescence of a Tungsten Tool Steel." By S. N. Brayshaw.
"The Welding of Steel in Relation to the Occurrence of Pipe Blow Holes and Segregates in Ingots." By H. Brearley.
"Open-hearth and other Slags—their Composition and Graphic Methods for Determining their Constitution." By J. E. Fletcher.
"Notes on the Cleaning of Blast-Furnace Gas." By S. H. Fowles.
"The Protection of Iron with Paint against Atmospheric Corrosion." By J. Newton Friend.
"On the Cause of Quenching Cracks." By K. Honda, T. Matsushita, and S. Idei.
"Slip-Lines and Twinning in Electro-Deposited Iron." By W. E. Hughes.
"Scientific Control of Combustion." By H. T. Ringrose.
"Comparison of Different Methods of Estimating Sulphur in Steel." By T. E. Rooney.
"Solid Solution of Oxygen in Iron." By J. E. Stead, F.R.S.
"Roentgen Spectographic Investigations of Iron and Steel." By A. Westgren.
"Cupric Etching Effects Produced by Phosphorus and Oxygen in Iron." By J. H. Whiteley.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

9203—Benko, R.—Manufacture of iodine, etc., compounds. March 26th.
8988—Chemische Fabrik Weissentien Gess.—Process for distilling sulphuric acid. March 23.
8858—Craig, E. N.—Reduction of oxides of tungsten and molybdenum. March 22.

Specifications published this Week.

160185—Marks, E. C. R.—Process for production of reactive acid liquor alcohols, esters, and the like from olefine hydrocarbons.
160258—Vickers, Ltd.—Toco Rubber and Waterproofing Co., Ltd. and Nuttall, W. H. Condensation of phenolic bodies with aldehydic compounds.
139803—Chemical Construction Co.—Apparatus for the manufacture of superphosphate of lime and similar compounds.

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Abstract Published this Week.

Messrs. Boake Roberts & Co. of Stratford, London, have been granted a patent No 157578, for a process of obtaining Diethysulphate. It is p epared by p ssing ethylene in great excess int) sulphuric acid, containing 81-100 per cent H_2SO_4, or into oleum cont ining up to 90.50, at a temperature of 120° C. Ethyl hydrogen sulphate is first formed and this is converted into diethyl sulphate by contin ing the introd iction of ethylene until the weight of the reaction has increased by at least 20 per cent of the weight of sulphuric acid present.

Ethyl hydrogen sulphate in any known manner may be used in the first instance as the absorbent for the ethylene.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK

Monday, April 18.

Royal Society of Arts, 8. "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry" by Dr. Samuel Judd Lewis.

Tuesday, April 19.

Royal Institution, 3. "Darwin's Theory of Man's Origin" by Prof. A. Keith.
Instituti n of Petroleum Technologists, 5.30.

Wednesday, April 20.

Royal Society of Arts, 4.30. "Thomson's Apparatus for Armless Men" by Sir James Cantlie.
Royal Microscopical Society, 8.

Thursday, April 21.

Royal Institution, 3. "Nationalisation and Bureaucracy" by Prof. H. S. Foxwell.
Institution of Mining and Metallurgy, 5.30.
Chemical Society, 8.

Friday, April 22.

Royal Institution, 9. "Electro-Synthesis in Organic Chemistry" by Sir James Walker.
Royal Society of Arts, 4.30. "The Common Service of the British and Indian Peoples to the World" by Col. Sir Edward W. H. Gr gg.
Technical Inspection Association, 7.30. "Physical Properties of Clay" by Alfred S. E. Ackermann.
Physical Society, 5.

Saturday, April 23.

Royal Institution, 3. "The Great Epoch of Exploration—Portugal" by Dr. H. Y. Oldham.

NOTICES.

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THE CHEMICAL NEWS.

VOL. CXXII., No. 3184.

FURTHER STUDIES CONCERNING GALLIUM.

ITS ELECTROLYTIC BEHAVIOUR, PURIFICATION, MELTING POINT, DENSITY, COEFFICIENT OF EXPANSION, COMPRESSIBILITY, SURFACE TENSION, AND LATENT HEAT OF FUSION.*

By THEODORE W. RICHARDS and SYLVESTER BOYER.

(Continued from p. 177.)

THE results for the density of the less pure material need not be given in full, but will be summarised.

Sample A (containing indium) was found, as an average of a number of determinations, to have the density of 6·162 as liquid at 29° and 5·975 as solid at 20°. No great difference was observed between the metal thus solidified in the pycnometer or solidified in air a little below the melting point on a block of paraffin. On the other hand, this impure gallium when solidified by dropping into cold water from a pipet, was found to give a lower result, about 5·90, probably due to included water, but possibly to be referred to the sudden solidification of a more bulky unstable alloy, which may not appear when the cooling is slow. Correcting the values for the solid to 29° by means of the coefficient of expansion, mentioned later, the value at 29° is found to be 5·974. The change in specific gravity of this impure sample on melting is therefore found to be 0·188; of Sample B, considerably purer, the change at 29°, corrected in the same fashion, was from 5·893 to 6·084, or 0·191; for sample C (several preparations) the average for four determinations of the solid was found to be 5·889, whereas four determinations of the liquid gave the value 6·079, a difference of 0·190.

Sample D, which was very nearly, but not perfectly, pure, gave, with three different preparations, the following values (two apiece) for the liquid at 29·8°, 6·090, 6·094, 6·093, 6·097, 6·098, 6·099; an average of 6·095, whereas for the solid at 29·6°, the following five values were found: 5·907, 5·908, 5·907, 5·905, 5·903, an average of 5·906, and a difference of 0·189.

* From the *Journal of the American Chemical Society*, February, 1921

The last and purest sample, E, gave essentially identical results, which are given in full in Table I. In these cases, the gallium was introduced into the pycnometer in the liquid state and solidified there under pure boiled water. The density of the solid was determined at 29·65°, and that of the liquid at 29·8° on the hydrogen scale.

The respective densities of pure liquid and solid at the melting point are, therefore, 6·0947 and 5·9037, the difference being 0·191; and the respective specific volumes of the two states of the metal are 0·16408 and 0·16939 cc., the difference being 0·00531 cc. Allowing for its coefficient of expansion, the density of the solid at 20° may be taken as 5·907 and its atomic volume as 11·85, if the atomic weight is 70·1.

Evidently, since the further purification between D and E produced no essential change in the density of either solid or liquid, and since the substance last measured had been heated for a long time in vacuum and purified by crystallisation, the densities recorded above for the gallium in the two states cannot be far from the truth. Table II., reiterating the change of density on crystallisation in the several specimens of increasing purity, shows conclusively that the impurities have nothing to do with the change of volume, since the variations are not greater than the possible variation due to experimental error.

TABLE II.

Sample	Average density. Solid.	Average density. Liquid.		Difference between density of solid and liquid.
A	5·974	6·162	More or	0·188
B	5·893	6·084	less	0·191
C	5·889	6·079	impure	0·190
D	5·906	6·095	Fairly pure	0·189
E	5·904	6·095	Very pure	0·191

Supposing that no great contraction or expansion takes place when indium is dissolved in gallium (which seems reasonable because of the similarity of the two metals), the percentage of indium in Sample A (its specific gravity being 7·31), is easily calculated approximately from the liquid to be 5·6 per cent, and from the solid to be 4·8 per cent. Evidently, Sample A must have contained about 5 per cent of indium. If contraction occurred on the solution of one metal in the other, the percentage thus calculated would be higher than the true value, and *vice versa*.

TABLE I.—*Density of Gallium.*

No.	Obs. wt. Ga.	Wt. in vac.	Wt. H_2O in vac. not displ.	Corrected vol. H_2O.	Vol. pyc.	Vol. H_2O displ.	Dens W/V.
			(Liquid.)				
1	9·0447	9·0452	5·8956	5·9209	7·4056	1·4847	6·092
2	9·0447	9·0452	5·8950	5·9211	7·4056	1·4845	6·093
3	10·1864	10·1870	5·7104	5·7348	7·4056	1·6708	6·097
4	10·1864	10·1870	5·7103	5·7347	7·4056	1·6709	6·097
						Av.	6·0947
			(Solid.)				
1	9·0447	9·0452	5·8943	5·8740	7·4056	1·5316	5·905
2	9·0447	9·0452	5·8487	5·8734	7·4056	1·5322	5·903
3	10·1864	10·1870	5·6563	5·6802	7·4056	1·7254	5·904
4	10·1864	10·1870	5·6558	5·6797	7·4056	1·7259	5·903
						Av.	5·9037

V. The Cubical Coefficient of Expansion of Gallium.

The direct measurement of the linear expansion of solid gallium was not easily made with the small amount of metal at hand, and, therefore, the cubical coefficient of expansion was found by determining the density of solid gallium at 0·1° and 29·65°. The volume of the pycnometer also was determined at 0·1° in order that any errors due to manipulation, to possible condensation of moisture on, or evaporation from, the pycnometer, &c., should be equalised. In this way in five experiments (from which the danger of condensation was excluded by warming the pycnometer before drying and weighing) the density varied between the extremes, 5·912 and 5·915, in average 5·9134 at 0·10 C., whereas the density at 29·65° had been found to be 5·9037. The increase in density is thus 0·0097, which corresponds to a cubical coefficient of expansion of 0·000055 or a linear coefficient of expansion of 0·000018.

Of course, any value obtained in this way has a large probable error, but it is better than nothing. This value is about one-third that for sodium, somewhat less than that for magnesium, aluminium, cadmium, thallium, or zinc, but not far from that for copper and silver. It is about midway between the values for zinc and arsenic, as would be expected from the fact that the atomic volume of gallium is also approximately midway between those of these two metals, near it on opposite sides in the periodic table (Richards, "Concerning the Compressibilities of the Elements, and Their Relations to Other Properties," *Journ. Amer. Chem. Soc.*, 1915, xxxvii., 1643; correction, 1915, xxxvii., 2696).

VI. The Compressibility of Gallium.

The method and apparatus have already been described in detail (for example, Richards and Jones, *ibid.*, 1909, xxxi., 161). The form of piezometer first used for the liquid was essentially like that employed for determining the compressibility of the rubidium-potassium alloy (Richards and Stull, *Carnegie Inst. Pub.*, 1907, lxxvi., 19). If solidified in this apparatus the gallium, of course, would have burst the containing tube. For this reason gallium was cast in a separate small glass tube, producing a cylinder of the metal from which the broken fragments of glass were wholly removed. This cylinder was placed in a slightly larger test-tube, and this latter tube was capped with a long glass cap. The whole was then placed in a still larger test-tube that came almost to the top of the cap, and a platinum wire held the combination together. In this way, solid gallium could be compressed under mercury, but protected from this liquid by the toluene underneath the cap. The contrivance was less simple than that used later for determining the compressibility of indium (Richards and Sameshina, *Journ. Amer. Chem. Soc.*, 1920, xlii., 49), but was adopted in this case for fear of melting the gallium accidentally, when it would have immediately amalgamated with the mercury.

The weighing of the toluene and mercury (which had been purified by usual methods) was effected as follows. The cylinder of the solid metal was placed in the inner test-tube and this tube was next filled with toluene in a vacuum. The cap (filled with toluene) was then placed over the test-tube while immersed in a larger vessel containing toluene, and the capped tube was placed in the larger test-tube while still under the liquid. After wiring the tubes together, a weighed quantity of mercury was finally added to the outer tube, replacing the toluene, and also holding the toluene beneath the cap. Enough toluene was displaced so as to make sure that no more would be liberated from the cap accidentally, and all toluene was removed from the surface. Since the weights of the glass, gallium, and mercury were known, that of the toluene was found very simply by the difference. It is necessary in such a case to know the weight of the toluene with great accuracy, since its compressibility is 30 times as great as that of gallium.

The assembled apparatus was suspended in a piezometer, essentially like that used in earlier researches (Richards and Stull, *Carnegie Inst. Pub.*, lxxvi., p. 11, pattern V., Fig. 2). The samples of gallium of which the compressibility was determined have already been described as Sample C. The purest sample, E, could not be used for this work, since there was not enough of it; but the amount of impurities could not have been enough in Sample C to exceed the probable error of measurement in its effect.

Following are complete data of two determinations of gallium, together with the measurements made with the piezometer alone. The figures in the last column, for the range 100 to 400 megabars (the megabar is the "absolute atmosphere," or 0·983 of the ordinary "atmosphere"), were taken from curves carefully drawn through the points defined by the proceeding data.

In order to apply the large correction due to the presence of the toluene, 26·538, 25·719, and 25·939 g. of this hydrocarbon were compressed separately in Piezometer II. and found to need mercury additions of 11·105, 10·578, and 10·820 g. respectively, between 100 and 500 megabars. Subtracting from each the value which was obtained in this piezometer with mercury alone (0·249 g.) and dividing by the weight of toluene in each case, values for the difference in added mercury over this pressure range produced by one g. of toluene, 0·409, 0·402, and 0·408 are obtained, in mean 0·406. The presence of the additional glass had an effect (in the contrary direction) of 0·0032 per g. These values were substituted in the equations already given (the most convenient for this purpose have the form given in the *Journ. Am. Chem. Soc.*, 1915, xxxvii., 471, with the addition of another term, 0·0032×5·86 in the parenthesis in the numerator to account for the glass container within the piezometer).

TABLE III.—*Data for Compressibility of Solid Gallium (at 20°).*

I.—Piezometer with 429·2 g. mercury alone.

Press. range.	Wt. Hg.	Press. range.	Wt. Hg.	Wt. Hg for 400 megabars
99·0-283·7	(0·1256)	283·7-478·7	(0·1263)	0·264
99·7-299·9	(0·1334)	299·9-495·9	(0·1245)	0·261
90·6-305·6	(0·1412)	305·6-499·0	(0·1236)	0·259
			Av.,	0·261

II.—Piezometer I. with 23·42 g. solid gallium, 0·871 g. toluene, and 5·86 g. glass test-tube con-

tainer (one of these trials was rejected as obviously in error, probably from a mistake in weighing).

88·0-359·3	(0·2397)	357·3-496·3	(0·5428)	0·560
115·0-275·0	(0·2397)	275·0-505·3	(0·5428)	0·561
130·6-302·8	(0·2505)	302·8-513·5	(0·5299)	0·564
			Av.,	0·562

III.—Piezometer I. with 19·47 g. solid gallium, 0·858 g. toluene, and 5·86 g. glass.

115·9-298·0	(0·2638)	298·0-510·1	(0·2716)	0·548
107·1-303·9	(0·2829)	303·9-494·1	(0·2472)	0·549
			Av.,	0·548

Thus two values for the compressibility of solid gallium are obtained: 0·0000024 and 0·0000016—in the mean 0·0000020. The comparatively poor agreement of the results is to be regretted; it is probably to be ascribed to the complication and consequent size of apparatus, adopted because of the low melting point of gallium. Although only preliminary, these results are, nevertheless, worth recording, since they are the only results for this constant which have been obtained.

Determinations of the compressibility of *liquid* gallium were less satisfactory and need not be recounted in detail; but they showed indubitably that liquid gallium is far more compressible than the solid, although it is more dense. The average of two determinations was nearly 0·000004—about the value for mercury. This is an interesting example of the rule to which no exceptions at moderate pressures have as yet been found: that liquids are more compressible than their solids.

VII. The Surface Tension of Liquid Gallium.

Mention has already been made, in brief extracts ("Carnegie Inst. Year Book," 1919, No. 18), of the work on the surface tension of gallium; the work is now to be described. For the present purpose, the flat-drop method often used for mercury (for example, Chwoison, *Lehrb. Phys.*, 1902, i., 602) is the most suitable, since, because of the property of adhering to glass possessed by gallium, the capillary-rise method could not be conveniently employed.

The flat-drop method consists in measuring the height between the greatest diameter of a large, flat drop resting on a horizontal surface and the highest level of the top of the drop, which must be large enough to have a perfectly flat surface in the middle. The drop, of course, must rest upon a surface which it does not "wet."

The mathematical expression for the computation of the surface tension reduces from a very complicated form to the simple equation $2\gamma = SA^2$, where γ is the surface tension, S the density of the substance at the temperature employed, and A the height in millimetres above the maximum diameter.

The work of Laplace (Laplace, *Mec. Cel.*, 1845, iv., 538), Quincke (Quincke, *Pogg. Ann.*, 1858, cv., 38), and Meyer (Meyer, *Wied. Ann.*, 1894, liii., 845), may be merely mentioned. Heydweiller (Heydweiller, *Ann. Phys. Chem.*, 1898, lxv., 311; see also Gnadenwitz., 1899, lxvii., 467), like Quincke, called attention to the necessity of a large drop and further proved that the form of a solidified drop was of little use in determining the surface tension of a solid. Stöckle (Stöckle, *Wied. Ann.*, 1898, lxvi., 499) showed that after remaining for hours in contact with a gas, the liquid usually showed a smaller surface tension than at first, the final values agreeing essentially with those observed in a vacuum. Evidently, then, one must wait until constancy is attained.

In our own experiments the gallium of which the surface tension was to be determined was supported on a plane surface at the bottom of a small box immersed under the water of an accurate thermastat and fed with an atmosphere of pre carbon dioxide. The box was of iron about 15×8×10 cm. On its front side was cemented a small plane window of optical glass, and in the rear a somewhat larger window-pane was secured. Both were sealed into place by a watertight paste made from litharge and glycerine, protected by a thin coating of paraffin. The top of the metal container was closed with a piece of mica with a small hole for introducing the metal.

The plane surface employed for supporting the liquid metal was at first a block of paraffin, later a block of hard wood, and finally, when contamination from this substance was feared, a small block of gas carbon. Paraffin becoming somewhat softened at 30° adheres slightly to the gallium, and even hard wood was not wholly free from this difficulty, but carefully smoothed and polished gas carbon proved to be a wholly satisfactory support. The box was coated both inside and out with paraffin to preserve the gallium should it be accidentally displaced, and to prevent rusting and leaking. The carbon dioxide was passed through a U-tube immersed in the thermostat in order that it might enter at the constant temperature. The thermostat itself, consisting of a large square metal box, had a window of plane optical glass both in front and the rear. Very great care was taken to have the front pane and that of the container box vertical and exactly parallel in order that there might be no error from refraction. This was accomplished optically by measuring by means of a perfectly horizontal telescope (that of the cathetometer used later for measuring the height of a drop), the position of a distant spot of light (on a level with the telescope), as reflected in these glasses. The carbon dioxide employed was made from pure marble, and purified by a saturated solution of sodium hydrogen carbonate (the water having been boiled to free it from dissolved oxygen) and concentrated sulphuric acid. Air must be excluded wholly in order to prevent oxidation of the gallium. The purest sample of gallium employed was Sample E, already described; melting at 29·75° it must have been very nearly, if not quite, chemically pure.

Mercury also was measured, to serve as a check. Several samples were employed, the best having remained for sometime under sulphuric acid with agitation and also having been sprayed six times through a tower containing dilute nitric acid as well as finally through one containing water to remove the acid. The mercury was subsequently dried in a large evaporating dish, distilled in a partial vacuum, and filtered.

Before reading the height of the drop, the liquid metal was allowed to remain on its carefully levelled platform in the small thermostatted container with the perfectly vertical window until constancy was surely reached. No change was observed with gallium after 20 or 30 minutes, although usually at least an hour was allowed.

Mercury attained constancy even more promptly than gallium. The drop of the latter metal must be occasionally shaken and even stirred on top with a glass rod, introduced through a tube from the top, otherwise inconstant values, above the final constant one, are obtained. Perhaps a very thin quite invisible film of oxide sometimes formed and exerted a disturbing influence, in spite of the great pains taken to exclude oxygen. Of course, the drop must be perfectly dry and wholly free from acids.

The measurement of the height of the drop above the point of maximum diameter was usually made by locating the latter with the help of a small carbon-filament lamp on the level with the telescope. A brilliant point of light obviously appears on the desired level, and it is easy (especially if the aperture of the object glass of the telescope is much reduced in diameter) to measure the distance between this point of light and the flat top of the drop. The measurement was made by an accurate eye-piece micrometer which was standardised by moving the telescope exactly 1 mm. and counting the number of turns on the micrometer head necessary to bring the image back to the cross hair once more, or by actually measuring a metal rule in the thermostat at the same distance from the telescope as the drop of metal to be measured. Both methods gave essentially the same result for the standardisation of the micrometer.

In order to test the size of drop necessary to give the maximum height, drops of mercury varying from 1·6 to 23 g. in weight were measured, and of gallium varying from 3 g. to 10g. At least 15 g. of mercury (producing a flat drop with a diameter of 15 mm.) was needed to give an approximately constant value. 8 g. of gallium giving a drop of the same diameter was apparently enough to give nearly constant results with this less dense substance. Probably, in order to attain the highest accuracy, even larger drops should be used.

The final determinations for mercury and gallium follow. The large letters designate the purity of the samples according to the descriptions already given; the small subscript letters indicate different fillings and settings of the apparatus Each figure given consists of the average of 18 to 20 readings. Preliminary experiments with impure materials in which the various conditions of experimentation were developed, are omitted. All of the final results are given in each case.

TABLE IV.—*The Surface Tension of Mercury at* 30°.

Final Determinations.

Setting	No.	Wt. sub.	Height drop mm. from max. diam.	Surface tension. Mg./Mm.	Resting on
b ...	1	18·132	2·5501	43·97	Wood
	2	20·446	2·5532	44·08	Wood
	3	23·384	2·5548	44·12	Wood
c ...	1	17·968	2·5509	44·00	Wood
	2	21·762	2·5493	43·94	Wood
	3	27·837	2·5532	44·07	Wood
e ...	1	15·7	2·579	44·96	Carbon
	2	20·7	2·580	45·02	Carbon
	3	15·2	2·572	44·73	Carbon
f ...	1	12·31	2·542	43·69	Carbon
	2	16·84	2·544	43·74	Carbon
g ...	1	12·65	2·528	43·21	Carbon
	2	15·24	2·531	43·31	Carbon
			Av.,	44·06	

The Surface Tension of Gallium at 30°.

Final Determinations.

Sample and setting.	No.	Wt. ga.	Height drop mm. from max. diam.	γ Mg./Mm.	Resting on
E*e* ...	1	8·11	2·467	36·61	Carbon
	2	10·05	3·463	36·54	Carbon
	3	10·05	3·458	36·43	Carbon
E*f* ...	1	7·97	3·470	36·69	Carbon
	2	10·04	3·473	36·75	Carbon
	3	10·04	3·473	36·75	Carbon
E*g* ...	1	8·35	3·461	36·50	Carbon
	2	9·96	3·470	36·67	Carbon
E*h* ...	1	8·54	3·454	36·36	Carbon
	2	10·00	3·458	36·43	Carbon
E*i* ...	1	8·30	3·458	36·44	Carbon
	2	9·92	3·461	36·41	Carbon
E*j* ...	1	8·94	3·463	36·44	Carbon
	2	9·88	3·464	36·55	Carbon
			Av.,	36·54	

The rather wide range in the case of mercury from 43·2 to 45·0 is greater than is desirable; it is doubtless due to the difficulty of adjusting all the optical requirements of the system to perfect uniformity. Since a great many different settings of the apparatus were made, it seems fair to conclude that the average has almost, if not quite, eliminated uncertainty from this source.

In the case of gallium the range is much smaller, probably because of increased experience and dexterity. The earlier experiments where the metal rested on paraffin and contained considerable indium were somewhat higher than the final ones made with purer substances and more satisfactory supports. These latter seem to leave little to be desired. In brief, then we find the surface tension of mercury at 30° to be 44·06 mg./mm. (which is very near that of Stöckle and other accurate experimenters), and that of liquid gallium to be 36·54 mg./mm. In terms of dynes/cm., the values become, respectively, 432·0 and 358·2, since $g=980{\cdot}4$ in Cambridge. Thus the surface tension of liquid gallium is about five times that of water.

VIII. *The Latent Heat of Fusion of Gallium.*

Berthelot determined the latent heat of fusion of gallium calorimetrically in the usual way, obtaining a value 19·08 calories per g. (Berthelot, *Compt. rend.*, 1878, lxxxvi., 786). We have used the somewhat preferable method, based upon the familiar equation of Clapeyron: The values in the equation $Q=T\ (V_l-V_s)\ dp/dT$ are easily determined with accuracy. In this equation, of course, T represents the absolute temperature, V_l-V_s the change of volume of a grm. of substance on melting, and p, pressure. Of course, since Q is always positive (that is, heat is always absorbed on melting), an increase in volume on solidification necessitates a negative temperature coefficient. The experimentation is most conveniently carried out according to the method used by Demerliac (Demerliac, *ibid.*, 1896, cxxii. 1117; solidification necessitates a negative temperature pressure required to maintain equilibrium in a mixture of the solid and liquid phase at a fixed temperature.

Our apparatus consisted of a piezometer similar to that used in the compressibility experiments, but of only quarter the size, and with a narrower capillary. Within this piezometer the gallium

was contained in a small open test-tube protected from the mercury on top by an inert liquid. Neither the gallium nor the surrounding liquids need be weighed. The thermostat was arranged so that it could be adjusted quickly at any desired temperature over the range of 2° or 3°, and was provided with an adequate heating arrangement which could be regulated with great nicety. In detail the operations were as follows.

The piezometer (having been cleansed thoroughly and dried in a current of air) was partly filled with mercury and placed in a larger vessel which was evacuated in order to remove air. The little test-tube containing a cylinder of gallium (cast as before) was then placed in the piezometer, covered with either toluene or water, and again partly evacuated to remove air. After the piezometer had been completely filled with toluene (or water) and the stopper (without lubricant) placed in position, a portion of the gallium was melted, and sufficient mercury was placed in the side arm of the piezometer so as to make contact at the platinum point when equilibrium had been reached at the desired pressure. Since the piezometer was used at practically constant volume, the respective amounts of the two phases of gallium had to be adjusted to this volume by cautions melting or freezing, accomplished by temporarily altering either pressure or temperature.

The melting point of gallium was thus determined at various pressures between 200 and 450 megabars, by finding the pressure at which equilibrium was reached at a definite long-maintained temperature. The pressures were measured by the absolute gauge already mentioned, and the temperatures were referred exactly to the international hydrogen standard. The first three trials were rejected as merely preliminary, although essentially like the later ones. All the others are given in Table V.

TABLE V.—*Change of Melting Point with Pressure.*

No.	Press in megabars.	Centigrade melting pt.	ΔP.	ΔT.	$\Delta P/\Delta T$.
(A)	1·0	29·752	—	—	—
4	348·9	29·047	347·9	—0·705	—495
5	441·1	28·859	440·1	—0·893	—495
6	248·2	29·242	247·2	—0·510	—485
7	248·7	29·242	247·7	—0·510	—486
8	443·2	28·842	442·2	—0·910	—485
9	349·7	29·045	348·7	—0·708	—493
		Av.	346		490

These figures naturally fall into three groups when classified according to pressure, but it is evident upon comparing Experiments 5 and 8 at the highest pressure that the possible error of experimentation is as great as the total range in the values of $\Delta p/\Delta T$. Therefore these figures are not accurate enough (because of the comparatively small pressure range) to determine the change of dp/dT with pressure. The best method of utilizing the results is to assume that their average applies to an average pressure, which must be taken as one-half of the average Δp, because $\Delta p/\Delta T$ is approximately equal to dp/dT at about the average pressure involved in the range Δp.

(To be continued.)

BRITISH WEIGHTS AND MEASURES AND THE METRIC SYSTEM.*

FACED with a demand in certain quarters for the compulsory adoption in Great Britain of the Metric System, the Conjoint Board of Scientific Societies appointed a Committee to report on, not the theoretical advantages of the metric system which are indisputed, but the necessity of making it compulsory in this country for all intents and purposes. The British system of weights and meausures has grown unscientifically almost from prehistoric times, and the system itself, as well as the use which has been made of it is unnecessarily complex and wasteful of time and arithmetic. Its defects, indeed, are so obvious that there has been for many years strong propaganda in favour of its eradication. Bodies such as the Decimal Association have assumed that the metric system is undeniably superior, and have perhaps made light of the very real difficulties of a change. With every increase in complication of technical processes and the establishment of each new scientific industry, it has been almost natural to work in the metric system, which became so well known in our factories and machine shops during the war, that the time was undoubtedly favourable for a radical change in our units of measurement. Nevertheless, the Committee of the Conjoint Board, have, after long and careful consideration, confirmed the opinion expressed by Lord Balfour of Burleigh's Committee on commercial and industrial policy after the war—that it is not desirable to make changes compulsory, except perhaps in one or two special trades.

It cannot be denied, that many scientific men, as well as propagandists, consider this verdict thoroughly reactionary. It is therefore worth while to examine the question with some care. The Metric Committee point out in their preamble that the terms of reference—the advisability or otherwise of compulsory adoption—removed the question out of the purely scientific sphere, and made it necessary to consider the effects in common life as well as in technical manufactures and industries.

They point out the great distinction between measuring and making to measure, the latter being in ordinary life far more common than the former. In the greater part of common manufactures and small trades it is a case of making, often rather roughly, to a few given dimensions, or of weighing and measuring to one or other of a relatively few units. The British units are not well related, and especially they rarely have decimal relations, but such as they are they are well established and perfectly standardised. When reformers speak of confusion in British measures they must mean either complexity in relations, or confusion in use, for there is no confusion in the measures themselves, as there was between the different varieties of foot and pound in Central Europe little more than half-a-century ago, or as there is to-day in the varying values of the maund in different parts of India. The British pound and foot of unvarying standard are thoroughly established in the world, and no one has the slightest difficulty in knowing what they

*Note on the recent Report on compulsory adoption of the Metr System, by the Secretary of the Committee.

mean. But they lend themselves ill to calculation, owing to the fact that the various units are not inter-related decimally, which makes them totally unsuitable for any scientific work, and far from convenient in any technical work, such, for example, as the simple process of making up a photographic developer. All this is common ground. Nevertheless, the Committee came almost unanimously to the conclusion that for the ordinary purposes of life the metric system is not superior to the British system, since it does not lend itself readily to the ingrained habit of subdivision to halves and quarters, a habit which no decimal system is strong enough to conquer. Moreover, the Committee believe that the advocates of a change have not paid sufficient attention to material difficulties. The trouble of changing all the weights and measures in the country would be trifling compared with the difficulty of providing all the sacks, barrels, glasses, jars, boxes, &c., which would be required if all sales were to be made in metric weights and measures from a given date. They point out that the inconveniences of a change of system are felt in each individual transaction, and that the quantity dealt in is relatively unimportant. The retail trade in small quantities would feel the weight of the change. It does not appear to the Committee that any changes desirable in the units of weight in the foreign trade require the abolition of the avoirdupois pound as the unit of weight in the internal retail trade of the country. A change in the unit of length immediately interferes with all standard sizes and fits, which would inevitably be perpetuated almost indefinitely alongside the new. For reasons such as these, which are fully set out and discussed in their report, the Committee recommend that the British system of weights and measures be retained in general use in the United Kingdom, but that serious attention should be given to their decimalisation and to the elimination of those which do not lend themselves readily to this purpose. They suggest, for example, the abolition of the pole, furlong, and the league, and the limitation of the link and chain to use in the determination of area; the abolition of the square rod or perch and the rood, all areas of land being in acres and decimals, or in square feet. In the measures of weight they propose the abolition of the grain, drachm, stone, quarter, and cwt. of 112lb., and the complete abolition of apothecaries' weight. In the measures of capacity, they suggest the general use of the gallon, with the customary subdivision into quarts and pints for retail use; the abolition of the peck, bushel, quarter, chaldron, and barrel, and the substitution of measure by weight. Finally, and this recommendation is as important as any, they insist on a more sensible use of the remaining measures, by confining each statement of measure to one unit—75inches, for example, instead of 6 feet 3 inches—and the more extended use of the central and thousand-weight, which are already much employed in certain industries. In one trade only, that of drugs and fine chemicals, do the Committee recommend the immediate compulsory adoption of the metric system. They recognise to the full, however, the inadequacy of the British system in all scientific and technical processes, and they suggest that reform in these should be brought about gradually, by agreement on the part of Government Departments, large companies, and contractors, to issue specifications and invite tenders in the metric system.

A draft of the Committee's report was submitted to the Constituent Societies represented on the Conjoint Board and their criticisms are printed in full. The purely scientific societies, such as the Physical Society, the Faraday Society, and the Royal Society of Edinburgh, express strong dissent from the recommendation; while the technical societies, such as the Electrical Engineers, the Engineers and Shipbuilders in Scotland, the Institute of Metals, Mining Engineers, Naval Architects, and others, are in general agreement.

PROCEEDINGS OF SOCIETIES.

PHYSICAL SOCIETY.

April 8, 1921.

Mr. W. R. Cooper in the Chair.

The following papers were read :—

"*A New Registering Microphotometer.*" By Dr. W. J. H. Moll, University of Utrecht.

A diminished image of a slit, on which the filament of a half-watt lamp is focussed, is projected by means of a microscope objective on the photographic plate or other object of which the absorption is to be measured. A second similar objective focusses an image of the slit, magnified up to its original size, on a second slit behind which is mounted a sensitive thermopile of the author's own design connected to an improved D'Arsonval galvanometer. By suitable gearing to an electromotor the photographic plate is given a slow motion at right angles to the beam of light, and at the same time a drum of photographic paper, on which the spot from the galvanometer is focussed, is caused to rotate at a suitable rate. A record is thus obtained of the density of the plate at different parts encountered by the beam of light. The arrangement is dead beat and so quick in response that intensity curves of close spectrum lines, Zeeman triplets, &c., are accurately recorded.

Discussion.

Mr. R. S. Whipple thought that the dead-beatness and quickness of the apparatus were unequalled. There was a beautiful feature of the records to which Dr. Moll had not referred; they showed the actual texture of the photographic plate as ripples on the base line. He believed the author was engaged in another research which would throw light on some important problems in connection with the blackening of photographic plates. It would be difficult for most of those present to imagine that the record of the Zeeman effect shown had been taken inside half-a-minute. It was a triumph of experimental skill.

Prof. Rankine said he had had the privilege of being about during the last few days when Dr. Moll and Prof. Ornstein had been erecting the apparatus. He had suggested that the instrument might be used to settle the question of the existence of the canals on Mars. In this connection Dr. Moll had told him that the eye saw many things which did not exist and missed many things

which did. An example which might be of interest to radiologists present was the case of an X-ray photo of a square hole in an opaque screen. It was frequently asserted that the intensity was greater at the edges of such a square than at the centre. The thermopile showed that this was wholly an illusion.

Mr. GUILD said he could only express the greatest admiration for the instrument they saw before them. He was particularly interested in the galvanometer. They had recently been installing radiometric apparatus in the Optics Department of the National Physical Laboratory, and were using a Paschen galvanometer. They were troubled so much with the zero changes due to stray magnetic fields from the adjacent electric railways and from sources within the laboratory that the advantages due to the sensitivity of the galvanometer were largely nullified. He looked forward with very great interest to the advent of Dr. Moll's thermopiles and galvanometers on the British market.

Dr. J. S. ANDERSON said he had had the pleasure of hearing Koch describing his microphotometer. He had thought the chief objection to Koch's instrument was the variability of the photo electric cell. The modern forms were much less variable, and probably the objection did not now hold to the same degree. Dr. Moll was, however, to be congratulated on so successfully employing the much more easily manipulated thermopile for the purpose.

Mr. C. R. DARLING thought the instrument would be readily adapted to form a recording radiation pyrometer.

Mr. F. E. SMITH said he would like to know how Dr. Moll had made such an excellent thermopile. Through the kindness of Mr. Whipple he had had the pleasure of working with one of them, and there was no question of its excellence, but he had not been able to see how it was made.

Dr. MOLL, in reply, said the secret of his thermopiles consisted of getting the junctions which received the radiation to be of very low heat capacity. With most thermopiles the bulk of the heat capacity was due to the solder at the junctions. His method of avoiding this was as follows: He took two thick plates of the metals to be used, constantin and manganin, and soldered them end to end, scraping off the excess of solder. The metals already joined in this way were then rolled out to the desired thinness, and cut into strips. In this way, strips only 2μ thick were obtainable with no excess of solder at the junctions. The other junctions were made of large heat capacity to give constancy of temperature of the "cold" junctions.

As regards the galvanometer, the principal modification which he had introduced was to have the coil held by two strips of bronze in tension instead of suspending it by the upper strip in the usual way. This gave greatly improved constancy of zero.

"*Application of the Ionisation Spectrometer to the Determination of the Structure of Minute Crystals.*" By. Sir W. H. BRAGG, F.R.S. (read in his absence by Dr. E. A. OWEN).

It is shown that crystals in the form of powder can be examined by the ionisation method. The powder is pasted on a flat surface and placed on the spectrometer table in the position ordinarily occupied by the face of a single crystal. A bulb current of 1 milliampere is sufficient to give satisfactory records.

DISCUSSION.

Mr. J. GUILD said that while listening to Dr. Owen, with the preceding Paper by Dr. Moll on improved thermo-electric meausurements still in his mind, he had been wondering whether the modern improvements in the methods of X-ray production and of radiometry had possibly brought us within reach of direct measurement of the energy of X-radiation. Using a sensitive thermopile with lead foil receiving plates, and a heavy discharge from a Coolidge tube, there might be sufficient energy stopped by the foil, although most of it would pass through, to give an indication on the galvanometer.

Prof. ORNSTEIN thought that insufficient energy would be stopped by the thermopile to produce any effect unless the lead was so thick that all the sensitivity of the pile would be destroyed.

"*A Balance Method of Using the Quadrant Electrometer for the Measurement of Power.*" By Mr. HUBERT PARRY (read in his absence by the Secretary, Dr. D. OWEN).

A new method of using the quadrant electrometer for the measurement of electrical power is described. It involves the use of a potential-divider across the supply circuit, and a standard non-inductive resistance in series with the load. An ammeter and a voltmeter are employed to measure the supply voltage and the load current. An example of its application to determine the power-factor of condenser is quoted.

DISCUSSION.

Mr. C. C. PATERSON said he had worked for 10 to 15 years with electrometers for power measurements. He would like to see the method tried out more fully under varying conditions. With small power-factors one always had the result as the difference of two large terms when using the electrometer.

Another point was that the two voltages V_1 and V_2 were not in phase. Of course, V_2 was small, but it would surprise him to find that it was legitimate to add them as the author had done.

Dr. E. H. RAYNER said they had not yet tried the method at the National Physical Laboratory, but were certainly going to. He wondered if the difficulty mentioned in connection with small power-factors could not be overcome by connecting the needle to the mid-point of a large dividing resistance. There was always a danger, however, with small power-factors that the dividing resistance was not true as regards phase on account of the distribution of capacity.

Dr. A. RUSSELL congratulated the author. The method was novel to him. The old method was quite good for high voltages, but for low voltages he thought the author's method would be superior.

Dr. D. OWEN said: The author's Paper, of modest dimensions, contains an idea which promises to add decidedly to the value of the quadrant electrometer as used for the measurement of electrical power. The method, being a null one, possesses several advantages. In the first place, it makes it possible to utilise to the full the possession of an electrometer of the highest sensi-

bility attainable in virtue of mechanical design. Further, as the constant of the electrometer disappears from the expression for the power, the usual calibration experiment with non-inductive load becomes unnecessary.

In the form proposed, however, the method has one decided disadvantage, namely, that at low power-factors the power required was obtained as the difference of two separately determined quantities, each of which might be of much greater magnitude. This is so, indeed, in the very test chosen by the author for illustration, and the effect is evident in the considerable discrepancy between two successive tests on the same condenser.

Dr. RAYNER has expressed the possibility of this source of error being overcome by connecting the needle to the mid-point of the non-induction resistance across the mains. This had occurred to me, and on trying it I found it to be the case. The adoption of this modification would not only eliminate the source of error occurring at low power-factors, but would simplify the expression for the power in the general case. Denoting by V/n the voltage drawn from the potential-divider (denoted by V_1 by the author) the expression for the power supplied to the load becomes

$$W = \frac{V^2}{R} \cdot \frac{n-1}{n^2}$$

All that is required in a test now is to adjust the tapping-point on the potential-divider until the electrometer needle is at zero, and at that instant to read off V on the voltmeter. n may be observed at leisure, and the only remaining factor in the calculation of the power is the standard non-inductive resistance R.

SOCIETY OF PUBLIC ANALYSTS.

Ordinary Meeting April 6, 1921.

MR. ALFRED SMETHAM, President, in the Chair.

CERTIFICATES were read for the first time in favour of Messrs. William Ellard Woolcott, Thomas Henry Pope, B.Sc., F.I.C..

A certificate was read for the second time in favour of Mr. Percy N. Mould.

The following were elected Members of the Society: Messrs. Jules Cofman-Nicoresti, Walter K. Fletcher, William Singleton, James Darnell Granger, Ph.D. (Berlin), F.I.C., Edward Bradford Maxted, Ph.D. (Berlin), B.Sc. (Lond.), Russell George Pelly, F.I.C., Francis George Henry Tate.

The following papers were read:—

"The Estimation of Strychnine in Scale Preparations containing Quinine and other Cinchona Alkaloids." By T. F. HARVEY, F.I.C., and S. BACK.

The determination of strychnine in a scale preparation containing iron and quinine is a matter of some difficulty. Existing methods for the separation of these two alkaloids are discussed. Some of these are useless, whilst others give satisfactory results on pure alkaloids, but fail when applied to the somewhat altered alkaloidal residues obtained in the analysis of scale preparations. The method recommended by the authors, which has so far proved satisfactory in practice, is based upon two existing methods, viz: the tartrate method of Harrison and Cair, and the ferrocyanide method of Simmonds. The greater part of the quinine is directly precipitated as tartrate from an aqueous solution of the scales, an aliquot part of the filtrate being used for the extraction of the strychnine and residual quinine, the separation being then completed by the precipitation of the strychnine as ferrocyanide. Characteristic strychinine residues are mostly obtained. Check experiments were made. The occurrence of small quantities of other cinchona alkaloids is shown not to interfere, with the exception of quinine, the behaviour of which is described.

"A Method for the Determination of the Acidity of Coloured Solutions." By J. L. LIZIUS, B.Sc., A.I.C.

The method consists of passing the approximately neutralised coloured solution through a filter paper previously treated with the indicator solution. Small quantities of standard alkali or acid are added to the solution, which is then refiltered, and this procedure continued until the filter paper gives the permanent colouration of the indicator.

"The Action of Water on Lead." By J. C. THRESH, D.Sc., M.D., F.I.C.

The author referred to the conflicting views held with reference to this action, notwithstanding the large number of chemists who have attacked the subject. He, therefore, commenced *de novo*, and found that water free from dissolved oxygen had no action on lead, but if free oxygen be present, action begins instantly, and continues until all the oxygen is used up, the rate of action depending on the amount of oxygen present. He then proceeded to enter into theoretical explanations as to the chemistry of the reactions which take place.

"A Colour Reaction for Aconite." By S. MELLANEH, M.D., D.P.H.

The author states that colour reactions at present known for aconite are really those of benzoic acid, and that colour reactions generally are seldom useful unless applied to pure alkaloids. He has devised a method which appears to be specific for aconite, and is very delicate, involving the use of potassium ferricyanide and formic acid. This the author considers very useful for medico-legal purposes, particularly in India, and it is applicable not only to the pure alkaloid, but also to the powdered root. He seeks confirmation of the test.

NATIONAL ASSOCIATION OF INDUSTRIAL CHEMISTS.

AT the Fourth Annual Meeting of the National Association of Industrial Chemsits held at Sheffield recently, and presided over by Mr. A. B. SEARLE, among other important business transacted was the reading of the General Secretary's report on the activities and progress of the Association during 1920, from which we note that:—

Although many difficulties were met with during the latter half of the year, chiefly as a result of the Coal Strike and the decline in trade, the N.A.I.C. came successfully through a period

which proved to be the most critical since its formation. At present there are nearly 1100 members on the register, and a slight gain in membership has been made: many other trade unions, on the contrary, were not so fortunate, and one union in particular has reported a loss of 50 per cent of its membership. The Secretary also states that there was a balance in hand at the end of the year, but this would not have been possible unless economy had been rigidly observed. The publication of a magazine by the Association was carefully considered by a committee, but was deferred on account of cost. The matter is not being lost sight of, however, as it is felt that such a publication would be of considerable value as a medium for keeping in touch with the members (especially those not attached to a Section), and also in making the Association's aims and objects more widely known. The amount of correspondence dealt with by Headquarters was particularly heavy, whilst reports on the Association's affairs have been published in the chief trade journals as occasion arose.

The President devoted much time in attending meetings of the various Sections, and in interviewing many of the individual members. He also gave lectures before the Sheffield Section, and his advice and assistance proved invaluable on numerous occasions. Indeed, the N.A.I.C. was very fortunate in being able to fill the vacancy created by Mr. Charlier's resignation from the Presidency so successfully. Full advantage was taken of the "Advice Bureau", and quite a number of members were helped with a variety of problems. Although much time and labour were spent in this way, the nature of the work does not permit of a detailed statement for publication. With regard to income tax rebates, it is interesting to note that a statement has been received from the Commissioners of Income Tax to the effect that, although rebates for damaged clothing, travelling expenses, scientific books, subscriptions, &c., cannot be granted indiscriminately to industrial chemists, members of the N.A.I.C. may put in a claim for such expenses if they are necessarily incurred in the course of their employment. The economic status of the members was always uppermost in the minds of the Association's officials, and a special committee was formed early in the year to consider and draw up a scale of minimum salaries. This very difficult and complex subject was tackled whole-heartedly by the committee, and eventually a scale was submitted to and approved by the National Council. A copy of the scale was then forwarded to all members with a request that any member receiving less than the minimum mentioned therein should communicate with the Secretary, who should then endeavour to secure an increase in salary. Although the Coal Strike and the slump in trade has interfered temporarily with this scheme, the results were satisfactory, and well over 100 members have received increases in salary. Even though these endeavours to obtain better pay were upset by unforesen circumstances, the experience gained goes to show that the Association has very good prospects of doing much better in this direction when trade is more normal. Another committee was also formed to discuss preliminaries with the British Association of Chemists in order to try and bring about an amalgamation. Several meetings have been held and many difficulties overcome. The negotiations are still proceeding. With regard to the employment bureau, there are now nine members on the register who are out of work, and 15 other members requiring a change of situation. Several members have secured situations with the Association's assistance, and two members have received considerable increases in salary. During the first eight months of the year, an average of one working day per week was involved in this service. There is undoubtedly a tremendous amount of work to be done in the interests of the industrial chemist, but first of all it is essential that every effort should be made to obtain a strong organisation, both numerically and financially, and one that is fully representative of the industrial chemists of Great Britain. It is possible that much headway may be made in this direction by amalgamation with the British Association of Chemists and possibly by affiliation with the "non-manual workers federation."

The Secretary also explained that it is imperative that every works chemist, both in his own interests and those of his fellow chemists, should belong to a trade union, and that it is his duty to make that union a strong one. Moreover, it is felt that there is a good chance of doing so because the works chemist, after the comparative safety which he has enjoyed during the last few years, now begins to realise that he must have his protective society like any other worker. Reference is then made to the work of the Local Sections which is both educational and social in character, and also to the invaluable support and assistance which has been rendered by the officers and councillors of those Sections.

All communications with reference to the N.A.I.C. should be addressed to the General Secretary, The White Building, Fitzalan Square, Sheffield.

NOTICES OF BOOKS.

Journal of Indian Industries and Labour. Vol. I., Part I. 111 Pages+7 Pages of Illustrations.

All who are interested in Indian industrial questions will welcome the appearance of the new *Journal of Indian Industries and Labour*, the first issue of which has just been published by the Government of India. There is a distinct need for more publications of this kind, and it is stated that the Journal is to be supplemented by a series of bulletins dealing with special subjects. The Journal, as Sir Thomas Holland explains in a foreword, has been started on the unanimous request of Directors of Industries, and "in addition to its functions as a bond of union between those who are working towards similar ends in different provinces, it is intended as a medium for communicating to a wider public, within and outside India, information that will assist private enterprise." The first issue gives every reason to believe that it will fulfil the purposes for which it is intended.

Sir Ernest Low, who has had a long acquaintance with industry and with the Central Provinces, contributes an article on "The Possibilities of Industrial Development in the Central Pro-

vinces and Berar," in which, after a survey of the industrial assets of the Province and a suggestive discussion of the labour problem, he deals with such questions as Government assistance to industries and banking facilities.

Mr. N. M. Joshi contributes a frank and independent article on "Welfare Work in Bombay Cotton Mills," a subject he has made peculiarly his own. We are glad to observe that the Journal does not identify itself too closely with the official point of view, and that contributions from non-officials are invited.

The article on "Researches in Tanning and the Calcutta Research Tannery," by the Superintendent of the Tannery, Mr. B. M. Dass, gives a full account of the valuable work that the Tannery is performing. It is interesting to note that there is a vigourous competition for admission into the tannery, and a keen demand for the services of the men it trains. In pure reesarch too, the results attained fully justify the enterprise. The article is illustrated by plans and photographs, and should stimulate interest in the leather trade, which has boundless possibilities in India.

A research of a different type, but no less practical in its conclusion, is illustrated by Mr. Gadre's article on "Clove Oil from Clove Stems." Mr. Gadre is Industrial Chemist to the Government of the United Provinces. His experiments go to show that the extraction of clove oil from clove stems can be profitably undertaken in this country, and it is hoped that some enterprising firm will make the attempt.

Captain Frankau, in a short article on "The Gilt Wire and Tinsel Industry at Burhanpur, Central Provinces," deals with one of the oldest of the smaller skilled industries of India.

Minerals are represented by "Trade Notes on Bauxite," by Dr. J. Coggin Brown, of the Geological Survey, who is at present attached to the Office of the Indian Trade Commissioner in London. This article—which is one of a series on Indian minerals about to be published in bulletin form—should prove most useful. After a description of the appearance, distribution, and uses of bauxite, the author turns to trade particulars and deals with grades and specifications, the organisation of the markets, prices, and the sources of competing supply. There are some useful statistical tables, and in conclusion, a short discussion of the outlook for bauxite in India.

An interesting discussion of the industrial unrest in Bengal during 1920 is given in "Trade Disputes in Bengal," by the Director of Industries. The article is supplemented by useful statistics giving particulars of the different disputes, with the numbers of men involved, and of days work lost.

Mr. Fyfe, in the concluding article on "Industrial Education in Madras Presidency," gives a thoughtful discussion of the reasons for failure in the past, and the conditions necessary for success in this line in the future. It is satisfactory to note that the question is receiving attention, not merely from Government, but from local bodies and private firms, and Mr. Fyfe makes a number of suggestions which should not be ignored by those who are interested in this very vital question.

In addition to the articles, the journal contains Summaries of Industrial Intelligence for the different Provinces, and some miscellaneous notes. The Provincial summaries, are, unfortunately, not complete, but most of the leading provinces are represented. These summaries give a review of industrial activity throughout India, and of the part that Government is playing in industrial development.

The Journal is in a handy form, the print is clean, and the paper good. The price for a single issue is Rs. 1-8; the yearly subscription (for four issues) is Rs. 4-80. Applications for copies should be made to the Superintendent, Government Printing, India, Calcutta, or to agents for Government publications.

NOTES.

Conjoint Board of Scientific Societies.—The Executive Committee of the Conjoint Board of Scientific Societies state that at the General Meeting of the Board held in March last it was decided to discontinue the publication of the "Annual Calendar" and "Fortnightly Bulletin of Scientific Meetings (Diary of Scientific and Technical Societies)," owing to the heavy printing liabilities incurred.

Canadian National Exhibition.—Applications for space from Canadian and American firms were reported in February last "to have been unprecedented for this time of year," and it would be advisable to forward applications at the earliest possible moment to the Secretary, Canadian National Exhibition, 38, King Street East, Toronto, Ontario, Canada.

Bulgaria.—According to a telegram which has been received in the Department of Overseas Trade from His Majesty's Minister at Sofia, the Bulgarian Ministry of Railways is calling for tenders, to be submitted by May 9 for 1000 tons of creosote and 50 tons of chloride of zinc. Further details are being forwarded, and will be available for inspection on receipt at the Department of Overseas Trade, 35, Old Queen Street, Westminster, S.W.1. It is advisable that firms tendering should act either through their own agents in Bulgaria or through some merchant firm established there. The names of suitable firms are also available at the Department.

Reversible Reactions of Carbon Monoxide on Iron Oxides.—Whether with ferric or ferrous oxide, as the latter is unstable below 580° C., only one equilibrium is possible below this temperature $Fe_3O_4+4CO \rightleftarrows 4CO_2+3Fe$. Above this temperature, on the contrary, there are two equilibriums before reaching iron. We have the Moissan processes:

$$Fe_3O_4+CO \rightleftarrows 3FeO+CO_2$$

$$FeO+CO \rightleftarrows CO_2+Fe$$

the three solid phases coexisting at 580° C. The composition of the gaseous phase could be followed with the refractometer. Constancy of temperature could be obtained by electric heating. Thus the curves of equilibrium can easily be formed.—*Comptes Rendus*, January 17, 1921.

Institute of Metals.—For the first time since its formation in 1908, the Institute of Metals will be paying in the autumn a return visit to a provincial city. This Meeting will be held in Birmingham on September 21-23, the first Autumn Meeting of the Institute having also been held in that city in November, 1908. Since then the membership of the Institute has grown from 200 to over 1350, so that the attendance at the first Birmingham Meeting, excellent though it was, should be quite eclipsed by that at the forthcoming Meeting. The arrangements for the September Meeting are in the hands of the Committee of the Birmingham Section of the Institute, of which Dr. H. W. Brownsdon, M.Sc. (Member of Council), is Chairman. The programme will include a reception by the Lord Mayor of Birmingham, visits to the University and works in the neighbourhood, as well as excursions in the locality. Persons desirous of attending the Birmingham Meeting as Members of the Institute should obtain the necessary application forms from the Secretary, Mr. G. Shaw Scott, M.Sc., the Institute of Metals, 36, Victoria Street, London, S.W.1, before April 20, when a Ballot for the election of members will take place. The subscriptions of members elected as a result of the forthcoming Ballot cover an extended period ending June 30, 1922. In addition to being able to attend the Birmingham Meeting, members elected as a result of the Ballot on April 20 will also have the privilege of being eligible to be present at the forthcoming Eleventh Annual May Lecture. This special Lecture, which is given each year by a distinguished metallurgist or engineer, is to be delivered at the House of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, on Wednesday, May 4, at 8 p.m., by Prof. T. Turner, M.Sc., A.R.S.M., the subject of the Lecture being "The Casting of Metals." Visitor's tickets are available for the use of non-members, and can be had on request being made to Mr. G. Shaw Scott, 36, Victoria Street, S.W.1.

Very Active Saccharose Preparations.—Treating 80 litres of crude yeast, during four days, at 28°- 25° C., with 100 of must and 50 of saccharose the percentage of saccharose is quintupled. The yeast thus treated, reduced by pressure to have 30·4 per cent dry weight, is subjected to autolysis at 15°- 16° C., in presence of toluol; then filtered. Saccharose is extracted with water from the residue of filtration and precipitated by alcohol. The solutions of this precipitate are yet a little turbid and probably contain proteinous matter. Treated with kaolin, and filtered, they are perfectly clear. Adsorption by kaolin causes loss of about 10 per cent. diastase. But activity per grm. of dry weight increases to about the same extent. The saccharose passes through the Chamberl and filter and collodion membranes; but dialysis improves the specific power of inversion and percentage of nitrogen in solution decreases.—*Bull. Soc. Chim. de France*, January 20, 1921.

Properties of Rubber.—According to O. de Vries, the general effect of steeping the coagulum in water is an extraction of substances from the serum, the result being a loss of weight of 0·2-0·4 per cent for crepe; 0·5-3 per cent for sheet; 0·2-3 per cent for non-rolled coagulum. The speed of vulcanisation is decreased. When steeping is prolonged there is a "maturation" with further loss of weight but an increase in speed of vulcanisation, so that the primitive retarding is decreased or transformed into an acceleration. Accelerators formed during "maturation" are only partially extracted by water. When, freshly rolled sheet rubber is steeped in water subsequent development of rustiness is not prevented, but greasiness is due to hygroscopic substances on the surface of the sheets, and tendency to development of moulds is prevented.—*Le Caoutchouc*, February 15, 1921.

PAPERS RECEIVED.

"The Metallic Hydrides and the Action of Hydrogen on the Metals." By E. Tomkinson. A Paper supplementary to that of Mr. J. F. Corrigan, Chemical News, 1919, cxix., 259. Received April 18, 1921.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

9361—Blummer, E.—Process for the continual distillation of tars or oils. March 29th.

9436—Kime, F. P. J.—*Refining hydrocarbon oils, spirits, etc.* March 30th.

9511—Kliva, Geo.—Manufacture of fatty acids from hydrocarbons March 30th.

Specifications published this Week.

142441—Strasser, A.—Process for deoidizing and refining copper.

137064—Darrasse Frères et Cie.—Process for the manufacture of valeric acid and of alkaline valerates.

139195—Gerber, V.—Manufacture of aluminium nitride.

Abstract Published this Week.

Vanadium Oxides.—Mr. P. A. Mackay of 70 Lombard Street, London, has recently been granted a Patent No. 157555 for a process of treating vanadium ores with oleum. The solution is reduced for instance by sulphur, dioxide or hydrochloric acid, or a carbonaceous reducing agent may be added to liberate sulphur dioxide from the solution, or in case chlorine is present in the ore, an added reducing agent may be unnecessary. The solution is then diluted with water and the lead sulphate separated, leaving vanadyl sulphate in solution. The vanadyl sulphate may be neutralized to precipitate hypovanadic acid, or an oxidizing agent such as alkali permanganate may be added to obtain vanadic anhydride, or the solution may be electrolyzed in a diaphragm cell, when vanadic anhydride separated at the anode and a lower oxide at the cathode.

Messrs. Rayner & Co., will obtain printed copies of the published specifications *and will forward on post free for the official* price of 1/- each.

MEETINGS FOR THE WEEK

Monday, April 25.

Royal Society of Arts, 8. "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry" by Dr. Samuel Judd Lewis.

Tuesday, April 26.

Royal Institution, 3. "Darwin's Theory of Man's Origin" by Prof. A. Keith.

Wednesday, April 27.

Royal Institution, 3. "Nationalisation and Bureaucracy" by Prof H. S. Foxwell.

Royal Society of Arts, 8. "Research in the Wool Industry" by Sir James P. Hinchliffe.

Society of Chemical Industry, 7. (At Nottingham).

Thursday, April 28.
Institution of Electrical Bngineers, 6.
Royal Society, 4.30. "The Vibrations of a Spinning Disc" by Prof. H. Lamb and R. V. Southwell. "The Hardness of solid Solutions" by Dr. W. Rosenhain "A Method of analysing Galvanometer Records" by W. Hartree and Prof. A. V. Hill. "A new Form of Wehnelt Interrupter" by F. H. Newman. "Some Experiments on Thermal Diffusion" by T. L. Ibbs. "Diffraction of Light incident at nearly the Critical Angle on the Boundary between two Media" by B. N. *Chakravarty.*

Friday, April 29.
Royal Institution, 9. "Advances in Astronomy" by Sir Frank W. Dyson.

Saturday, April 30.
Royal Institution, 3. "The Great Epoch of Exploration—Spain" by Dr. H. Y. Oldham.

THE BRITISH CAST IRON RESEARCH ASSOCIATION.

DIRECTOR OF RESEARCH.

THE Council invite applications for the post of Director of Research to the above Association. Applicants must state age and full particulars of training, experience in General Metallurgy, and especially in Cast Iron Foundry practice, Laboratory and Research Work. and st te salary required.
Applications endorsed "Director" should be addressed "The Chairman, British Cast Iron Research Association," and to be received by May 9th, 1921.
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NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

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T. G. SCOTT & SON,
63, LUDGATE HILL, LONDON, E C.4.

PATENTS, TRADE MARKS. Handbook and advice free—B. T. KING, British and U. S. Regd. Patent Attorney, 146a, Queen Victoria St., London. 35 years reference

BEILSTEINS ORGANISCHE CHEMIE, Volumes 1 and 2 (1920) £4. Thorpes Dictionary of Applied Chemistry, 6 volumes, £2. ALLCHIN, 92, Monton Road, Eccles, Manchester.

CHEMIST with Cement Works experience wanted for a Cement Factory in healthy part of India. Applicants should state age, whether married or single, salary expected, and should enclose copies of testimonials. Three years agreement with free passage out and home. Box 831, c/o T. G. SCOTT & SON, 63, Ludgate Hill, London, E.C.4.

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THE CHEMICAL NEWS.

VOL. CXXII., No. 3185.

EDITORIAL.

THE recent Friday Evening Lecture at the Royal Institution, London, was delivered by Professor SIR JAMES WALKER, F.R.S., of Edinburgh University, on "Electrolysis and Electro-Synthesis."

After briefly explaining the meaning of the terms "Electrolysis" and Electro-synthesis," in which reference was made to the two men whose names will always be honoured in connection with the Royal Institutions—Davy and Faraday—the Professor gave a brief account of the electrolytic work of Davy, which led to the isolation of sodium and potassium. The synthesis of ethyl-malonated was successfully carried out upon the lecture table and also that of di-ethyl-succinate; this latter was performed in an apparatus furnished with two platinum electrodes, and the inflammability of the gas was demonstrated by blowing it into a soap solution and ignition. An identical procedure, using one electrode of platinum and the other of gold, gave rise to the production of oxygen, forming an explosive gas, which was demonstrated in the same way.

The lecture was well attended, and many prominent chemists were present.

It is usual to hold an Exhibition on these occasions, and opportunity was taken for a display of British-made chemical and other glassware. The apparatus shown was produced by James Powell & Sons (Whitefriars), Ltd., Wood Bros., of Barnsley, and John Moncreiff, of Perth, for whom Messrs. Powell are now acting as retail agents in London.

"Powell's" are one of the few remaining glassmakers in London, and they are shortly removing their glass-works to Wealdstone, Middlesex, where an up-to-date glass-making factory on a very large scale is being erected. Meanwhile the firm is extending its manufactures, and is producing scientific glassware, chemical and thermometer tubing, and many other articles.

The Exhibition included a fine collection of Art and cut-glass table-ware, Mosaic tablets, and glass for church decoration. A very fine window panel was shown in course of construction, and the method of painting upon glass with vitreous pigments was explained and demonstrated by one of their staff of artists. Great interest was shown by the chemists present in the chemical ware; beakers, flasks, boiling-tubes, and other necessities of the laboratory were exhibited, and appeared to be equal to the very best pre-war productions. This confirms the contention that the British glassworkers need only time to accustom themselves to the formation of the articles hitherto almost exclusively produced upon the Continent, to be able to construct them with equal excellence. Hard combustion tube, soft soda, and flint tube, enamel lens front, and coloured tubes of all kinds were shown.

The beakers and flasks were made by the firm of Wood Bros., of Barnsley, and John Moncreiff, of Perth, and the combination speaks well for the spirit of comradeship as one result of the war; British manufacturers are co-operating with one another, each firm specialising in one or other direction. In the case in point, the association of these three manufacturers will make it possible to purchase the products of any one of them in the show-rooms which Jas. Powell & Sons are shortly opening in Wigmore Street, W. It will be a distinct advantage to the users of scientific and medical glassware to obtain the very best English ware direct from the producers.

Another exhibit of the Company consisted in a large collection of lamp-blown articles, an industry which has recently been taken up by them; already at Wealdstone large workshops are in full swing, producing medical and other lamp-blown apparatus, the labour being almost exclusively carried out by young girls. Some of the articles are of a most intricate nature; atomisers, syringes, and ampoules of all descriptions were shown.

A still further exhibit was a large collection of really beautifully made artificial eyes. This craft needs very special enamels and other coloured glasses, and all the eyes shown were manufactured from "Whitefriars" material. The work is carried out by the firm of Wm. Halford, Senr., who for some generations have been engaged in the art, and it has been carried to a marvellous stage of perfection. The eyes when worn are absolutely indistinguishable from the living eye. Miss Carne, one of the proprietors, was present to explain the process of manufacture and exhibits.

Our chief object in describing this remarkable exhibition is to emphasise the fact that British glassmakers are actively preparing to make their country independent of foreign manufactures in the matter of glassware, and that technical difficulties have already been overcome. All that is needed is a temporary measure of protection during the early years of the industry, while labour is being trained. Furthermore it requires help to enable it to withstand the artificial conditions due to inequality of exchange, and the determined effort of our ex-enemies to throttle the British glass industry by "dumping," a process often encouraged by the middleman, who is, unfortunately, in many instances ready to allow prospects of immediate profit to outweigh all national considerations.

The importance of the glass industry cannot be too insistently brought before the country, and it is encouraging to see that the glassmakers at least are not only talking, but doing their best for the good of the nation.

ROYAL INSTITUTION.—On Thursday, May 5, at 3 o'clock, Dr. C. S. Myers delivers the first of two lectures at the Royal Institution on "Psychological Studies: (1) the Localisation of Sound, and (2) the Appreciation of Music." On Saturday, May 7, Prof. E. C. C. Baly begins a course of two lectures on "Chemical Reaction." The Friday Evening Discourse on May 6 will be delivered by Sir Robert Robertson on "War Developments of Explosives," and on May 13 by Dr. W. Bateson on "The Determination of Sex."

THEORY OF MOLECULAR REFRACTIONS.

By GERVAISE LEBAS, B.Sc.

Part I.

SEVERAL systems of molecular refractions have at one time or another held the field. Those which are most noteworthy are the systems of Brühl and Eisenlöhr (for the Lorenz-Lorentz formula). The latter is an advance on that of Brühl, because it preserves a better relation between the atomic refractivities for the spectral lines α, δ, β, γ, and in several instances the atomic values are better calculated. It moreover embodies some important generalizations on the influence of substitution, especially of ethenoid links, and systems of unsaturated combinations. It also attributes a number of exaltations of the refractive value to the influence of the supplementary valencies. The system, however, labours under several important restrictions. One is—that the values for CH_2 are not always the most probable ones, and the value chosen for hydrogen, H_α 1·094, is not correct. The system is thus not adapted to a very close analysis of the data. The writer, who has traversed the whole field, endeavours to remedy these defects, and seeks to considerably augment the theory. Previous papers: *Trans. Faraday Soc.*, 1917, xiii., 1, Sept.; 1918, xii., 3; and another.

If it is desired to consider measurements for the different lines, it is usual to consider the magnitudes relative to those for H_α with differences (Dispersions). Comparisons can be made more satisfactorily, as follows. Eisenlöhr does so by calculating percentage differences

$$\frac{M_\gamma - M_\alpha}{M_\alpha} \times 100.$$

Thus, whilst these calculations involve relative dispersions, a better method seems to be to consider relative refractivities,

$$\frac{M_\delta}{M_\alpha}, \frac{M_\beta}{M_\alpha}, \frac{M_\gamma}{M_\alpha},$$

and to plot the ratios on a diagram against wavelength. The curves can then be compared. The refractivities for most substances vary very little in the region of M_α but the curves gradually become steeper as the wave-lengths diminish, until between β (483$\mu\mu$) and γ (430$\mu\mu$) there is a sharp upward bend till they become almost vertical.

The magnitude of the ordinates indicates the extent of what is known as unsaturation. When the compounds contain a complex unsaturated system, that is, one involving the conjugation of a number of unsaturated combinations, the ordinates at H_α may be very much increased.

Relation between Refractivity and Valency.

Traube has pointed out a very simple relation between the two:—

C 4×0·78; N 3×0·78; O 2×0·78.

The writer has recently calculated the atomic refractivity of combined fluorine, and finds that it varies between 0·67 and 0·84. There are sufficient indications that the numerical relation is not illusory, but is significant. If the molecular refractivities of carbon monoxide and dioxide be compared, the relation is found to be very exact:—

C : O	Δ	O : C : O
5·04	1·68	6·72
$N_\alpha O$ 1·68		$N_\alpha 2O$ 3·36
3·36		3·36
4×0·84		

Thus: C^4 4×0·84; O^2 2×0·84. It can also be shown that the augmentation for the addition H_2O and HCl to —O— in dimethyl pyrone is 1·54 beyond the atomic refractivities. Since H^α—O— 1·76, the value for O^4 = 1·76+1·54 = 3·30 (4×0·82). This result is similar to that for carbon.

The atomic refractivities for carbon and oxygen on the ordinary system is C 2·50; O 2·24. There is consequently a depression of the carbon below its value previously calculated —0·86, and an augmentation of oxygen by 0·56. From this point of view the former would be negatively, and the latter positively unsaturated. Thus the view of the unsaturation of a system depends upon how we approach the subject. Since negative anomalies are an undoubted fact on the ordinary system, this side of the question must be considered. It is too much to hope that the valency relation can be generally applied; it nevertheless affords an extension of our knowledge.

Since refractivities measure the space occupied by the electrical atom or molecule, these dots would represent small electrical charges (possibly electrons). The augmentations observed are related in such a way as to indicate small charges connected with the number of valencies concerned.

The Relation of Anomalies for Substitution and Valency.

Δ	R—OH		R—O—R		
	1·48		1·62		1·76
		+0·14		+0·14	
	R—SH		R—S—R		R—S—R[1]
	7·76		7·96		8·13
		+0·20		+0·37	
	R—SeH		R—Se—R		
	10·88		11·02		
		+0·14			

The case of substitution by hydrogen in carbon by methyl or other alkyl groups leaves no doubt as to the origin of the augmentation

		Δ
Split chains and substitution of ethenoid and acetylenic groups by CH_3		+0·14
Substitution of cycloparaffins...	>CH—CH_2	+0·14
Substitution of benzene	: C—CH_3	+0·28

The augmentation 0·14 is characteristic of the methyl substitution, but the amount is doubled in benzene; half for the union with >CH— and half for the unsaturation. There is some indication that the augmentations are the result of accumulated electrical charges at the unions, for in some cases, especially in multiple unions, the augmentation vanishes as if short-circuiting took place.

Nitrogen.—A minimum value for nitrogen is H^α 2·12—2·20. This is found in elementary nitrogen N_2, nitric oxide N : O, and : N in some ring compounds. Taking this as the datum line, the augmentations for substituted nitrogen can be considered.

		Amines.		
N.	NI.	NII.		NIII.
2·20	2·32	2·46	2·76	2·90
	2·20	2·20	2·20	2·20
	+0·12	0·26	0·56	0·70
	—	2×0·13	4×0·14	5×0·14

It is thus seen that the electrical charges depend not only on the number of substitutions, that is, on the bound valencies, but also in multiple substitutions on the supplementary valencies. The series can thus be represented graphically

—>NH$_2$ —>N or —>N —>N:

or —·NH$_2$ >:N— or >:N: —>:N:

These relations thus afford a clear indication of the connection between the augmentation for substitution and the fundamental or supplementary valencies. One has thus to consider two parts:—

$$A + \Delta A$$

A a fundamental unsaturation of the atom ΔA is an augmentation which is due to substitution, and which must be added to the fundamental unsaturation to produce a new atomic value or considered separately. There might thus be a slope of potential from the nitrogen to the carbon, or the carbon to the nitrogen. The connection of a depressed value for multiple linked nitrogen is a very significant fact, and shows that multiple linking does not always involve an augmentation or positive anomaly, but a depression.

The anomalies indicate retardation of the right waves due to some cause. Since matter does this, and this is partly made up of electronic centres, the anomalies seem to be due to the presence of these in the edges of the atoms or more in the paths of the light waves than in the saturated compounds.

Note.—In considering the hydrocarbons from the valency point of view, gaseous methane possesses a refractivity of M_α | 6·72 8×0·84. The carbon atom thus shows an exaltation (on the old system) of 0·84, and the hydrogen 1·06—0·84=0·22, which, of course, is one-fourth of the total augmentation. The old system compromises matters by calculating from a mean condition.

One other consideration must be noted. Substances involving a number of alkyl radicles can be arranged according to the complexities of these radicles.

R—O —H R—O —R^1
R—CO$_2$—H R—CO$_2$—R^1

R—NH$_2$ R—NH—R^1 R, R^{11} >N—R^1

R$_1$—NH$_2$

There will be disturbances differing with the position of the significant group, that is, with the complexity of the alkyl groups. The atomic refractivities are smallest when the significant group is terminal. It is required to accumulate data to such an extent as to be able to ascertain the disturbance throughout a series, and to arrange them as Dobriner did for the boiling-points and molecular volumes of the ethers, and Gartenmeister did for the carboxylic esters.

The Value of CH$_2$

This subject has been frequently dealt with, but it does not seem to have been treated very scientifically. When a hydrocarbon becomes substituted by a reactive group X, the combination —CH$_2$—X usually results in an augmentation for substitution. When X represents Cl, Br, I, OH, SH, &c., use is made of the ordinary values for the halogens, &c. These have been calculated from such homologous series.

The values for CH$_2$ throughout the series are found by means of the formula

$$H_\alpha \, CH_2 = \frac{M_\alpha \, C_n \, H_{2n+1}X - N_\alpha \, X}{n}$$

The curves as a rule show an initial depression, followed by a rise to the constant value for the series.

When the substituent is CO$_2$H, there is an initial augmentation for substitution. The ordinates which are large for the first member diminish greatly to the third, that is, as the alkyl groups neutralise the unsaturation. After this, the curve follows the previous one as the influence of the hydrocarbon element becomes preponderant.

In some cases there is a tendency to a maximum at some intermediate point, *e.g.*, in the case of the cyclo-paraffins. The maximum is at C$_6$H$_{12}$.

The disturbance for the combination CH$_2$—X, where it exists, is no doubt not only confined to the methylene group, but also to the substituent. It is possible that one or the other may be subject to a positive anomaly, whilst the other may be depressed. It has been assumed that X is constant throughout the series. Our knowledge is too limited to make a pronouncement on the subject, but this subject will be dealt with as it arises. It is, however, to a large extent a relative matter, and depends upon our datum line. The point is, are we to refer the exaltation to R or to X? It is becoming the practice to indicate such a disturbance by a thickened line CH$_2$—X. The writer proceeds differently, and indicates the unsaturation by a single, double, or triple dot. Since refractions measure the space occupied by the electrical atom or molecule, these dots would represent electrical charges (possibly electrons), and also would occupy space. The augmentation observed are relative in such a way that the connection with linkages (bound valencies) and the supplementary valencies is evident.

The relative values for CH$_2$ are always the same.

α	δ	β	γ
—	1·0046	1·0155	1·0245

Three main series are useful in calculations:—

(a)	4·58	4·60	4·65	4·692
(b)	4·60	4·621	4·671	4·713
(c)	4·612	4·633	4·683	4·725

The constants for hydrogen are:—

1·06	1·065	1·076	1·086

The constants for carbon can be found by difference.

The first series is useful for all open chain compounds up to a complexity, C$_{10}$ say. The second is as a general mean value. The third is especially useful for the cyclo-paraffins, aromatic and terpenoid compounds. It must be stated that these differences are small as compared with those for general unsaturation.

The Activation of Supplementary Valencies.

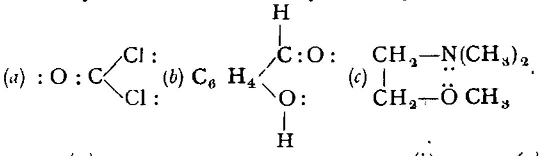
The case of nitrogen has just been studied. The halogens also show similar relations. Comparison is made between their refractivities under ordinary circumstances and when combined with unsaturated carbon.

	CH_2—X	Δ	: C—X
F	0·67	0·17	0·84
Cl	5·96	0·22	6·18
Br	8·79	0·23	9·02
I	13·87	0·25	14·12

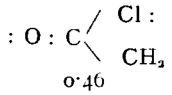
There is a slight progressive increase in the value of Δ from fluorine to iodine. The graphic representation of the second series is : C—Cl : for example. The augmentation is due to the stimulating effect of the unsaturated carbon. The only principle to guide one in this case is analogy. There is nothing to show that the augmentation is not represented by : C=Cl. It may, however, be noted that the value of Δ approximates to 2×0·14

The activation of the supplementary valencies may be due to the influence of unsaturated atoms other than carbon:

Carbonyl chloride. Salicyl aldehyde.



(a)		(b)	(c)
0·70	M ...	34·03	0·52
3×0·23	Phenol ...	27·75	4×0·13
acetyl chloride	Benzaldehyde	31·77	
		59·52	
	Less C_6H_6 ...	25·93	
0·46	Calc. ...	33·59	
2×0·23	Obs. ...	34·03	
		0·44	
		2×0·22	



Many cases are found among the xanthates and other compounds. It is evidently not always necessary for the unsaturated atoms to be connected by unsaturated carbon, although this is usually the case. This augmentation is distinguished from the ordinary anomaly. The above cases seem to show clearly that it is the supplementary valencies which are activated. The ordinary linking is only susceptible to an augmentation of 0·14 or 0·28 at most. It is noted (1) that atoms of high atomic weight are more likely to activate one another than those of lower; (2) the effects are greater if the atoms are united by an unsaturated group than a saturated one.

Peroxides :—

—O—O— 2×1·76

Disulphides :—

Et—S—S—Et 36·33
20·44
———
15·89
15·92 2×7·96

Diselenides :—

C_3H_7—Se—Se—C_3H_7
32·38
29·60 $(C_3H_7)_2Se$ gives Se 11·12
———
22·78
22·24
———
0·54
2× 0·27

Sulphur may, however, be much more activated owing to combination with unsaturated groups to form a series (*vide ante*).

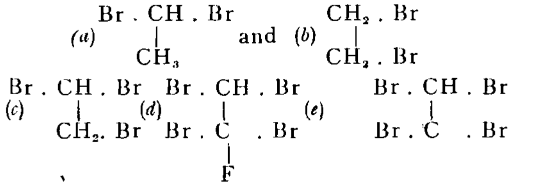
Karvonln has found from a comparison of the acid chlorides, bromides, and iodides, and other halogen series, that the disturbances augment from chlorine to iodine :—Cl > Br > I.

It is found that phosphorus, arsenic, and antimony are difficult to deal with owing to unlooked for augmentations. A detailed investigation of substances containing these and other heavy atoms is proceeding in various directions, and the conditions are much more complicated than in hydrocarbons.

The question of the influence of substitution is specially dealt with under definite circumstances—geometrical isomerism, keto enol charge, &c. One case may be mentioned at this point, viz. :—

The Influence of Massed and Distributed Substitutions.

If comparisons be made between



(a) Average Br 9·07; (b) 8·82; (c) 8·84; (d) 8·86; (e) 8·61.

The following are instructive :—

	$(CH_3)_3C.CH_2Br$	Δ	$(CH_3)_3.CCHBr$
Mδ	31·83		38·58
		6·75	
		1·06	
		7·81	
C_5H_{11}	24·06		23·00
Br	8·83		17·66
E	32·89		40·66
M	31·83		38·58
	Δ —1·06		— 2·08

Δ Br —1·05

This depression is remarkable and belongs to a class of compounds distinguished by *negative* anomalies, as already shown for furfurane and thiophene.

$C(CH_3)_2.(CH_2Br)_2$ is normal.

The conditions (a) + anomaly; (b) normal; (c) —ve anomaly thus await exact explanation.

The unbalanced condition results in a higher refractivity than the balanced or symmetrical one. The compound $CBr_3.CBr_3$ would doubtless show a larger depression still.

A comparison between corresponding chlorides, bromides, and iodides would show disturbances of magnitude depending on the halogen

Chlorides < bromides < iodides.

[Electrons are regarded as material nuclei : + central and accumulative, —ve kinetic and energy dissipating. They are thus unsaturated centres.]

FURTHER STUDIES CONCERNING GALLIUM.

ITS ELECTROLYTIC BEHAVIOUR, PURIFICATION, MELTING POINT, DENSITY, COEFFICIENT OF EXPANSION, COMPRESSIBILITY, SURFACE TENSION, AND LATENT HEAT OF FUSION.*

By THEODORE W. RICHARDS and SYLVESTER BOYER.

(Concluded from p. 185.)

ONE other point must be taken into account before applying the Clapeyron equation, namely, the change of $V_l - V_s$ with change of pressure. Since the solid is less compressible than the liquid, although more bulky, this change of volume on melting will increase as the pressure increases. Ordinarily this correction has been left out of account in the application of this equation, but it was properly heeded by Bridgman in his paper on "Water, Liquid and Solid, under Pressure" (P. W. Bridgman, *Proc. Am. Acad.*, 1912, xlvii., 471). The case of water is, of course, similar to that of gallium. Since the cubic compressibility of the liquid per megabar is about 0·000004 and that of the solid about half as great, the correction to be applied to the volume change over 173 megabars will be 0·00034 cc. per cc. of the metal, or 0·00006 per g. The value for $V_l - V_s$ at the atmospheric pressure is —0·00531. Hence at a pressure of 173 atmospheres it must be —0·00537.

We have now all the data needed by the Clapeyron equation:

$$Q = T\ (V_l - V_s)\ dp/dT$$
$$= 302{\cdot}5\ (-0{\cdot}00537)\ (-490)$$
$$= 79{\cdot}6 \text{ joules}$$
$$= 19{\cdot}04 \text{ cal. per g. (at 173 megabars pressure).}$$

This value is very nearly the same as Berthelot's 19·08, but since the latent heat of melting of gallium, like that of ice, probably changes with pressure, the identity is perhaps not as close as it appears to be. Nevertheless, the two figures cannot be widely discrepant, even applying the as yet unknown correction for pressure. Probably dp/dT also changes with pressure, as Bridgman found in the case of ice; and if so, it probably changes in such a direction as to counteract, or perhaps, even reverse the effect of the change in $V_l - V_s$. The decision concerning this matter must be left to future investigations. Unless a much wider pressure range is employed, the measurements of both ΔP and ΔT will have to be made with the utmost accuracy in order to solve the problem.

The value of $\Delta P / \Delta T$ given in the foregoing table is equivalent to a change in the melting point of 0·00204° per megabar, or nearly 0·00207° per atmosphere. (P. W. Bridgman, in a research of which a description is now in the press, found the nearly equal quantity 0·00203° per kg./cm^2. with a small quantity of our gallium. The megabar is 0·987 atmosphere or 1·02 kg./cm^2.). This change in the melting point is more than twice that produced upon ice under the same conditions.

We are indebted to the Carnegie Institution of Washington, as well as to an anonymous fund, for generous support in this investigation, and also to Mr. F. G. McCutcheon, of the Bartlesville Zinc Company, for his courteous presentation of part of the material used as the source of gallium.

Summary.

This paper contains a description of experiments leading to the following conclusions.

I. (*a*) The observed single electrode potential of gallium was not easily reproducible at a constant value. It reached in maximum only about —0·30 volt in 0·1 *N* solution (if the calomel electrode is taken as +0·56 volt), apparently placing gallium between indium and zinc in the electrochemical series.

(*b*) On the other hand, gallium is distinctly more difficult to precipitate electrolytically from acid solutions than zinc. According to repeated experiments, gallium might be expected from this behaviour to have a single electrode potential of at least —0·7. It can be precipitated in weakly acid solutions if sufficient current density is employed, however.

(*c*) A possible explanation of this apparent inconsistency is to ascribe a mild degree of passivity to gallium—an explanation borne out by the fact that this metal when pure precipitates copper only very slowly from its solutions.

II. After preliminary purification by electrolysis, which easily eliminates indium and many other metals, pure gallium was freed from zinc by ignition in a high vacuum and especially by crystallisation, giving material of constant melting point.

III. The melting point of gallium was found by two methods to be 29·75° C. on the international hydrogen scale.

IV. The density of the purest gallium was found to be 5·904 and that of liquid gallium 6·095, both at the melting point. The expansion on solidification (0·00531 cc. per g.) was proved not to be due to impurities.

V. The cubic coefficient of expansion of solid gallium was found to be about 0·000055. Hence the density of the solid at 20° is 5·907, and its atomic volume 11·85.

VI. The compressibility of solid gallium was found to be 0·0000020, and that of the liquid about twice as great.

VII. The surface tension of liquid gallium in carbon dioxide at 30° was found to be 36·54 mg./mm. In control experiments with the same apparatus, that of mercury at the same temperature was found to be 44·06.

VIII. The latent heat of fusion calculated from the Clapeyron equation and the change of melting point with pressure was found to be 19·04 calories per g. at 173 megabars pressure; that is, the melting point is lowered 0·00207° by the increase o fpressure of one atmosphere.

SILICIC ACID.

By VICTOR LENHER.

THE relations of silica and water in the so-called silicic acids and the silica gels, and the mechanics of the solution of silica by water, are problems which for many years have received a great deal of though by chemists and geologists. The following experiments, which have been extended over a period of years, have been carried out largely to obtain a better knowledge of the relations that silica and water bear to each other.

* From the *Journal of the American Chemical Society*, February, 1921

*Effect of Fine Grinding on Silica.**

The starting material was Ottawa sand containing over 99 per cent. of silica. It was ground for 400 hours by means of large rounded pieces of quartz in an Abbe ball mill. This period represented the actual time of grinding, although the attendant operations and the grinding were conducted daily for several months. Great care had to be taken to prevent caking. The average fineness of the ground material was no more at the end of 400 hours than it had been at the end of 350 hours; and by evaporating in platinum with hydrofluoric and sulphuric acids it was found to contain 98·72 per cent., showing that a slight amount of impurities had been introduced from the grinding apparatus. Measurements were made of the size of the ground silica particles by placing samples on a glass slide, moistening with water, and covering with a cover glass. The samples were then examined with a microscope with a calibrated ocular and showed that 85 per cent. of the material had a diameter of less than 0·004 mm., while 15 per cent. was between 0·004 and 0·016 mm. in diameter.

This finely-divided material was shaken up with 500 cc. of conductivity water and allowed to settle at room temperature in tall, glass-stoppered cylinders. W. Machaelis in a paper read before the German Portland Cement Manufacturers on March 9, 1909, states that quartz reduced to an impalpable powder by prolonged grinding becomes so active that boiling with water will convert it into colloidal hydrated silicic acid. When the heavier particles had completely subsided, and the supernatant liquid appeared homogeneous but not completely transparent, the liquid was examined by evaporation of 100 cc. portions to dryness in a platinum dish and the residue volatilized with hydrofluoric and sulphuric acids. The results of this procedure indicate that in from two to three weeks silica to the extent of 0·028 to 0·032 g. per litre remains permanently in solution.

When first shaken with water, the ground silica forms a mechanical suspension and a large part of the suspended matter settles quickly. In a short time the finer particles form strata which at the end of about 10 days disappear, and at the end of 15 days the solution is stable.

Colloidal Character of the Silica in Water.

When viewed with the ultramicroscope the fine particles which remained suspended in the water after the ground silica had been shaken and the whole allowed to settle for several weeks, showed a rapid Brownian movement.

When a powerful beam of light was passed through the liquid in a beaker the exhibited Tyndall effect was produced.

These experiments show that if quartz is ground sufficiently long, it can be so finely divided that it will go into colloidal condition when treated with water.

From the rate that the particular material worked with settled out from water, it would seem that up to two weeks the whole is a more or less coarse suspension which slowly settles and finally leaves a stable colloid.

*With G. G. Town.

*Experiments on Fine Grinding of Orthoclase**

Carefully selected orthoclase was ground for 388 hours in an Abbe ball mill. The mill was opened daily and the caked material dislodged. This material was shaken up with water and allowed to settle in the same way as has been described with quartz. An additional experiment was conducted by shaking the finely ground feldspar with alcohol. After settling, both the alcohol liquid and the water liquid of the orthoclase showed the Brownian movement when observed with the ultramicroscope and also gave the Tyndall effect. The water suspension was filtered through a Chamberlain F. filter, and was then optically empty, but when filtered through an acid-hardened filter-paper (Schleicher and Schüll, No. 602), it showed particles which exhibited the Brownian movement. This should fix the size of the particles as between 4μ and $1{\cdot}3\mu$.

Samples of this extremely finely powdered feldspar which had been suspended in alcohol for a short time were decanted, and the alcohol evaporated off and heated in an autoclave with water. One g. portions of this material, heated with 100 cc. of water in a platinum dish, for three hours at 168°, corresponding to 50 kg. steam pressure, showed an alkalinity against 0·1 *N* hydrochloric acid equivalent to less than 0·5 per cent. of K_2O, indicating that only a small portion of the feldspar had actually gone into true solution.

Action of Water at Elevated Temperatures on Quartz.

As is known to those who have worked with water in glass and siliceous material of various kinds at high temperatures and pressures gelatinisation takes place. From the many experiments with silica and water which have been conducted in this laboratory, it would seem that the first thing which takes place when silica is wet is hydration. Some of the silica then passes into solution and if allowed to remain in contact with water will finally reach the solution equilibrium shown by Lenher and Merrill (Lenher and Merrill, *Journ. Am. Chem. Soc.*, 1917, xxxix., 2630). Along with this process of hydration and true solution that portion of the silica which is sufficiently fine goes into the colloidal condition. When the temperature is raised this hydration takes place so rapidly that it can be readily followed.

At 400° in the sealed high-pressure bombs of Morey, water will slowly gelatinise all of the fused quartz or silica ware on the market to-day. At 500° water will slowly cause the gelatinisation of transparent quartz crystals. The resulting silica gels differ widely in character, depending on the temperature and pressure, and also on the original quartz used. Some of the gels when air-dried go to a loose, finely-divided powder; others dry into concentric layers and into fairly adhering compact plates.

Some recent experiments made by G. R. Shaw show that certain fused quartz tubes, when heated to about 500° with water in a bomb, on cooling give evidence of recrystallisation on the sides of the tubes. Numerous fragments were noted which under the polarising microscope showed

*With G. G. Town.

optical activity and also showed hexagonal structure.

Some preliminary experiments made by O. J. Noer with the finely-ground quartz prepared by G. G. Town seemed at first sight to be very significant. At 100° in a bomb, water hydrates this ground material in a manner which appeared to be definite. A number of experiments seemed to show by *analysis* that metasilicic acid, H_2SiO_3, was formed, the results of various experiments agreeing to within a few hundredths of 1 per cent, and agreeing exactly with the theoretical percentage requirements of the formula H_2SiO_3. However, the material which to the naked eye appeared homogeneous, when examined under a polarising microscope proved to be far from homogeneous. In reality it consisted of the broken fragments of the original quartz, interspersed with masses of gelatinous silica; it was, therefore, not metasilicic acid, but a physical mixture of silica gel and quartz. This hydrated material when allowed to dry spontaneously in the air hardened to a compact coherent mass which in texture, hardness, and general appearance much resembled quartzite.

The action of water at various temperatures and pressures on silica and on silica gels has been studied by Walter T. Schrenk in considerable detail. Several hundred experiments were made in a Morey bomb at temperatures which varied in the individual experiments from 300° to 600°, and the lengths of time of the experiments varied from 8 hours to 312 hours. The experimental difficulties to be overcome in work of this character have been almost insurmountable. While thus far it has been impossible to obtain the quantitative measurements that are desirable, it can be said in general that the extremely finely ground quartz previously described hydrates at 300° to 450° in presence of excess of water to a gel containing 15 to 18 per cent of water. On the other hand, silica gels made by the dialysis of the sodium silicate-hydrochloric acid mixture and containing 2·33 per cent of silica, the remainder being chlorine-free water, when heated from 300° to 600° in the bomb with great excess of water, lose water, and in from 8 to 312 hours yield a product containing approximately 20 to 30 per cent of silica and 70 to 80 per cent of water.

*Effect of Pressure on Silica Gels.**

The salts of orthosilicic acid, H_4SiO_4, and of metasilicic acid, H_2SiO_3, are found among some of our best-known silicate minerals. The free acids themselves are compounds that have plenty of analogues in the fourth group of the periodic system of which silicon is a member. Our common sodium silicate itself is a substance whose composition depends entirely on the quantities of reacting substances used in its original formation.

A very suggestive method described for the formation of orthosilicic acid is that of Norton and Roth (Norton and Roth, *Jour. Am. Chem. Soc.*, 1897, xix., 832). Their method of producing gelatinous silicic acid by passing silicon tetrafluoride into water is considered by them to be a method particularly desirable in order to obtain the material free from non-volatile foreign matter. They washed the gelatinous mass with water on a cloth filter and allowed it to drain a short time, after which the water was removed by ether or benzene.

*With Andrew J. Snyder.

The washed acid was then squeezed in a vise and an orthosilicic acid of constant composition reported as a definite body.

In our studies with silica these particular experiments seemed of sufficient promise to follow out in more detail. The particular points which looked attractive were a study of the effects of various and measured pressures on silica gels. If silica gels can be dehydrated by pressure from the condition of a high degree of hydration to the definite hydrate of the formula H_4SiO_4, it would seem that by using various pressures it should be possible to plot a curve showing the relation between pressure applied and the water remaining with the silica.

For the preparations of gelatinous silica it was most convenient for us to hydrolyse pure silicon tetrachloride. The gel was washed with water until free from chlorides, after which the excess of water was removed by squeezing the product between cloths by hand. The gel at this stage contained between 80 and 90 per cent of water and was preserved in a glass-stoppered bottle for use.

In place of the vise used by Norton and Roth, who could in this device obtain only about 100 kg. pressure per square inch, a Riehle testing machine was used. By means of a machine of this kind it is possible to obtain a compression of 45,400 kg. to the square inch, and to apply any particular pressure up to 45,400 kg. that is desirable.

In the first experiments, comparative low pressures were used. 230 kg. pressure, which is probably what a good vise would give, gave a mass which contained 77·7 per cent of water; 340 kg., 71 to 73 per cent of water; 454 kg., 68·5 to 71 per cent of water; 680 kg., 50 to 67·5 per cent of water; 900 kg., 46·5 to 53·5 per cent water; 1800 kg., 51 to 52 per cent water. In these experiments the gels were pressed between sheets of Whatman's filter paper, but at pressures of 2300 kg. and upwards, the adherence of the product to the paper became so pronounced that it was found necessary to use a canvas filter cloth as the medium to absorb the water. With 4540 kg. pressure, the water retained by the silica was from 57 to 60 per cent. At pressures from 4540 to 13,600 kg., various combinations of canvas filter cloth and hardened filter paper with copper foil gaskets were used. The water content then dropped down to 44·5 per cent at both 9000 and 13,600 kg. At 13,600 kg. two sheets of heavy rubber were also tried as a support for the gel, but 55 per cent of water still remained. In another series of experiments a laboratory diamond steel mortar was used at pressures of 11,600 and 13,600 kg. with the results that about 30 per cent. of water remained. The results obtained with the diamond steel mortar were so encouraging that it was decided to use tool steel plates.

Two carefully faced round steel plates 100 mm. by 12·5 mm. were used and as the water was squeezed out of the gel, the free water was removed by means of filter paper. The amounts of water remaining with the silica was of the same general order as with the other devices employed. The product in each case, after being pressed, looked, in the ordinary sense of the word, dry. Using the tool steel plates a pressure of 44,600 kg. was attained, yielding a product which retained 34 to 35 per cent water.

In order to continue the experiments at still higher pressures, two special chrome-nickel-steel plates, kindly furnished us by Dr. Geo. W. Sargent, of the crucible Steel Company of America, were carefully machined in such a manner that their contact surfaces were parallel to within 0·00508 mm. From the contact surface to the outer edge of the discs they were slightly bevelled to take up the flow of the steel at very high pressures. These plates withstood the pressure of 272,700 kg. very well, and the results obtained were fairly constant. A Tinius Olsen hydraulic press was used to obtain this high pressure. The product obtained showed a water content of 12·3 to 12·9 per cent, which closely approximates the ratio of one molecules of water to two of silica, corresponding to the formula $H_2Si_2O_5$. The final product was a white amorphous powder, which under the microscope showed no crystalline structure.

A number of the gels, after being pressed to 272,700 kg., were transferred to desiccators and allowed to stand for various periods of time. The material which was approximately two molecules of silica to one of water actually contained 12·5 per cent water, and in two months desiccation over phosphorus pentoxide lost 5·75 per cent of water, but still retained 6·75 per cent; while the material which was dried further over calcium chloride retained at the end of two months 9·24 per cent of water. Longer desiccation would doubtless remove more water.

From the results obtained by submitting gelatinous silica to the successively high pressures studied, should it be possible to press a silica gel more strongly than has been done, it seems probable that more and more water would be removed as the pressure increased.

From the observations made by Lenher and Merrill (*loc. cit.*), it is obvious that silica possesses a very definite solubility in water.

When quartz is ground sufficiently fine, pure water alone will cause it to go into the colloidal state as has been verified by actually finding it to be a colloid. Additional evidence of the fact that fine grinding alone can sub-divide a substance so finely that water will cause it to go into colloidal form, is afforded by the fact that orthoclase when ground extremely fine goes into the colloidal form in exactly the same general manner as does silica itself.

The action of water on silica is therefore that of a solvent, to produce the silica gel, and to cause it to go into the colloidal form. The more finely divided the silica the more rapid is the action. This action of water on silica with the subsequent hydration is accelerated by heat and with water under high pressures, such as are obtained in the steel bombs, the hydration of large-sized quartz crystals or even fused quartz can be readily followed.

The silicic acids themselves are purely hypothetical. While their salts form our common silicate minerals, the acids in free condition have never been prepared. The so-called "silicic acid" and the gels which are so common should therefore be regarded as corresponding to the general formula $XSiO_2YH_2O$ in which the quantities of water and silica can vary from a true solution of silica in water, successively through the highly hydrated gels which pressure alone will convert from a water content of nearly 98 per cent to a silica which contains only a few per cent of water.—*Journal of the American Chemical Society*, March, 1921.

PROCEEDINGS OF SOCIETIES.

FARADAY SOCIETY.

Tuesday, March 22, 1921.

PROF. ALFRED W. PORTER, F.R.S., President, in the Chair.

THE PRESIDENT delivered his Presidential Address entitled "Some Aspects of the Scientific Work of the late Lord Rayleigh." He indicated that Rayleigh's work was of many varieties. The experimental part could be divided into that requiring elaborate apparatus and laborious application such as in the case of the determination of the ohm, and investigations in which the apparatus was of the simplest kind. The latter was a type of investigation in which Rayleigh specially delighted. His mathematical work was always looking forward to its applications. Illustrations were given of the great use he made of the method of dimensions when problems (especially those in hydrodynamics) cannot be yet solved in any other way. His theoretic work on intrinsic pressure was outlined and contrasted with more recent work of the Dutch School of Physicists. Finally, his mentality was further characterised by references to his excursions into problems dealt with by the Society of Physical Research. His position was summed up by saying that although Rayleigh founded no school yet he so advanced knowledge of physics in all its branches as to stand out as one of the leaders in scientific achievement.

Papers were also read by Mr. S. Field on the "Electrolytic Recovery of Zinc"; by Prof. Alexander Findlay and Mr. V. H. Williams on the "Electrolytic Reduction of Glucose"; and by Mr. W. E. Hughes on "Iron Deposits."

CORRESPONDENCE.

COAL TAR FOR CAIRO.

To the Editor of the Chemical News.

SIR,—I beg to inform you that a cable has been received in this department from the British Commercial Agent in Egypt (Mr. E. Homan Mulock), stating that tenders are invited by May 15 for the supply of 1000 tons of coal tar to the Roads Office, Tanzim Department, Cairo, to be delivered between July 1 and October 15. Alternative prices can be quoted for British Standard Specification No. 2 or any coal-gas tar suitable for road spraying. The conditions of tender are those usual in contracts made by the Egyptian Government, and it will be observed that tenders will only be accepted from firms having agents or representatives resident in Egypt. It is understood that no special form of tender is required, though a sample of the tar offered must be submitted. In view of the conditions of this contract, United Kingdom firms, without representation in Egypt,

may, it is thought, care to avail themselves of the services of a firm with an Egyptian branch, through which tenders could be submitted, and I shall be pleased to forward you particulars on receipt of a request to that effect.—I am, &c.,

L. N. Barker,
for Comptroller-General.

Department of Overseas rade,
April 21, 1921.

HEBREW UNIVERSITY AT JERUSALEM.

To the Editor of the Chemical News.

Sir,—At the Third Annual Conference of the Inter-University Jewish Federation held at Oriel College, Oxford, on August 3, 1920, it was unanimously resolved, in response to a request of the Zionist Organisation, to render every possible assistance to all efforts on behalf of the Hebrew University at Jerusalem. The most urgent need at the present juncture is an immediate and abundant supply of books for the Jerusalem University Library. We can conceive no cause more precious and commendable than the full development and firm consolidation of the intellectual and spiritual resources of the Jewish National Home. To this end books are the first requisite. In a scarcity of books the mind of a people is denied free expansion and healthy growth. To Jews, with their love of learning, the want of books is most distressing. In Palestine, unfortunately, there is a real book famine, and even with help from all over the world, it will need a great effort to build up the present University Library of about 40,000 volumes, into an up-to-date library worthy of the Jewish University.

Serious works dealing with all branches of knowledge, standard works of fiction in any language, and more especially books which will be of use to University students are needed. Books on Hebraica, Judaica, and Semitica, mathematics, physics, chemistry, microbiology, and medical research are, however, the most urgently called for, as the first departments of the University that are to be opened will deal in research in these subjects. Books on law, economics, history, and philosophy will also be much appreciated. Sets of scientific journals, transactions of learned societies, official reports and other publications and works and pamphlets of permanent value are especially required; good text-books of established repute will also be useful.

Considering that this is an important step towards a spiritual revival of Palestine, and that our credit as an enlightened people is at stake, we appeal to your readers to send all the books they can spare as a free-will offering to those who will treasure them in Palestine. A single book will be welcome; but it is hoped that donors will send as many as they can. Gifts of books may be sent either direct to "The University Library, Jerusalem," or to the Hon. Secretary, Mr. D. B. Stanhill, B.Sc., F.I.C., 75, Great Russell Street, London, W.C.1, who will, if necessary, arrange for the collection of the books. An artistically designed book-plate, the generous work of Mrs. L. Pilichowski (Lena Pillico), will permanently record the names of the donors.—We are, &c.,

S. Alexander, *Chairman*
Israel M. Sieff, *Treasurer*
D. B. Stanhill, *Hon. Scretary*
Harry Dagul, *Chairman, I.U.J.F.*

NOTES.

Board of Trade Announcement.—The Board of Trade announce that by notice published in the *London Gazette* of April 8, the provisions of Section 11 of the Aliens' Restriction (Amendment) Act, 1919, which imposes restrictions on the acquisition by former enemy aliens of certain kinds of property, have been applied to the following industries, namely, the manufacture of synthetic organic dyestuffs, colours, or colouring matters, and the manufacture of organic intermediate products used in the manufacture of synthetic organic dyestuffs, colours, or colouring matters. The effect of this is to make it unlawful for any former enemy alien to acquire either in his own name or in the name of a trustee, any interest in the industries in question, or any share, or interest in a share, in a company registered in the United Kingdom which carries on the industries.

In the *Astrophysical Journal* for March an important paper appears by R. A. Millokan, I. S. Bowen, and R. A. Sawyer, on the "Extreme Ultraviolet Spectrum of Carbon, Iron, and Nickel." By the use of a special form of grating and a vacuum spectrograph, the authors have succeeded in obtaining records of iron lines from λ 2152·9 to λ 271·5 AU, carbon from λ 1931·1 to λ 360·5, and nickel from λ 1859·7 to λ 731·0.

British-American Alliance.—With a view to further cementing a happy relationship established some time ago with organisations in America and Canada, propagating similar objects to their own, namely, the improvement of relations between employers and employed, the Executive Committee of the Industrial League and Council recently decided to send a delegation to America for the purpose of conveying fraternal greetings, but primarily to study economic conditons and ascertain the possible channels through the medium of which a revival of trade can be stimulated. The idea has received the cordial approbation of large organisations of employers and employed on the other side of the Atlantic, and amongst the messages which have been received by Mr. John Ames, General Secretary of the Industrial League and Council, is the following cablegram: "Civic Federation will warmly welcome delegates of Industrial League. Congratulations upon happy turn in your great industrial conflict.—(Signed) Ralph M. Easley." It is evident from the last sentence that both employers and employed in America have closely watched developments in the Coal struggle. The Federation in question is the National Civic Federation of America, of which Mr. Samuel Gompers, President of the American Federation of Labour, is a vice-president, and the organisation embraces within its ranks all the big employers and representatives of labour in the United States. Mr. L. J. P. Benn, C.B.E., Hon. Treasurer, and Mr. Frank Elliott, a member of the Executive Committee, are the delegates from the League. They are sailing on the 23rd inst., and while in the States it is their intention to devote particular attention to the problem of the readjustment of wages in view of the falling prices, and the steps which are being taken to re-establish overseas trade. An interesting tour has been mapped out which will include all the big indus-

trial centres between New York and Kansas and Chicago and Quebec. The Industrial League entertains high hopes that as a result of the visit, and the establishment of more intimate relations with American manufacturers and employers, a great step forward will be accomplished towards the revival of trade.

Tenders Invited for Australia.—H.M. Senior Trade Commissioner in Australia has forwarded copies of specifications, conditions, and forms of tender in connection with calls for tenders by the Postmaster-General's Department for the supply and delivery of (1) ironwork, including couplings, piping, bolts, rings, &c. (Schedule No. 704); (2) 29,500 porous cells, No. 1 size to specification (Schedule No. 1685); (3) 20½ tons ammonium chloride (Schedule No. 1683). Sealed tenders on the proper forms will be received by the Deputy Postmaster-General, Perth, Western Australia, up to May 25 in the case of (1), and by the Deputy Postmaster-General, Melbourne, Victoria, up to May 31 in the case of (2) and (3). Local representation is essential, and as the time for the receipt of tenders is limited, it will be necessary for firms tendering to instruct their local agents by cable. Copies of the specifications in connection with the above tenders may be consulted by British firms interested at the Department of Overseas Trade (Room 59), 35, Old Queen Street, Westminster, S.W.1.

The Casting of Metals.—Prof. T. Turner, M.Sc., A.R.S.N.I., of Birmingham University, will deliver the Eleventh Annual Lecture at the Institute of Metals on this subject on Wednesday, May 4, at 8 p.m. The meeting will be at the Rooms of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. Coffee and light refreshments will be provided at the conclusion of the lecture.

Revival in Manufacture of Linoleum.—The actual penury of linseed oil, colophony, Kauri gum, jute, and cork, as also their high prices, constitute an obstacle to revival of the linoleum industry. By utilising all the accumulated waste, German works were able to resume manufacture, but this resource will only provide for a brief period, the quantity of waste materials being insignificant. Moreover, these works are equipped for a somewhat great production, and all reduction necessarily involves a loss in working. Linseed oil is the most important raw material, but considering its cost other oils are sought after. Whale and shark oil, prices of which are moderate, can, by direct oxidation, be made suitable for linoleum, combined with linseed oil and small quantities of wood oil. By insufflattion of air, as in methods for rapid oxidation, these oils lose their bad odour. By subsequent fusion with colophony, the odour completely disappears, so that the finished products are quite free from a fish oil odour. These oils can also be polymerised in presence of free fatty acids and magnesia; then converted into linoleum, compounds yielding oxygen being added. Other oils may also be employed, viz., perilla oil, soja, grape pips, hemp, walnut, poppy, and sunflower oils, &c. As a substitute for linoxin the pitch of stearin works can be utilised, or colophony can be replaced by rubber resins. These last have the advantage of not forming combinations with zinc, oxide, magnesia. or lime, differently to colophony, which forms very hard products with them, which make linoleum brittle. To avoid these inconveniences, when these polymerised oils are employed with magnesia, it is well to previously etherise the colophony with glycerin. Hardening is less to be feared with demi-siccative oils. Cork can be replaced by peat or sawdust, and jute by paper tissues.—*Chimie et Industrie*, January, 1921.

Variation in the Rotary Power of Tartaric Acid.—Continuing the study of this variation, which is different to that previously given, M. R. de Mallemant examines the action of solutions of metallic chlorides and nitrates. The fall increases in the series of alkaline metals and decreases in the order Sr, Ba, Mg, Zn.—*Comptes Rendus*, January 17, 1921.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

10508—Farberke vorm. Meister, Lucius & Bruning.—Manufacture of ,sodialk-ylaminoethylaracy oxybutyric acid esters. April 9th.

9927-9928—Hadden, P.—Process for converting organic acids into esters. April 4th.

10315—Lo, Monaco, D.—Chemical fertilizers. April 7th.

10493—Passmore, F. W.—Manufacture of magnesium-salts. April 6th.

Specifications published this Week.

137288—Thibault, J. A.—Method of converting metallic lead into oxides.

156080—Wacker, Ges, Elektrochemische Industrie, Dr. A.—Manufacture of dichlorethylene.

Abstract Published this Week.

Lead Sulphate.—Mr. P. A. Mackay of 70, Lombard Street London, has been granted a Patent No. 157554 for an improved process of obtaining lead sulphate by treating the sulphide ores free from zinc, preferably galena and oleum, which may be in excess without any external heating. The reaction vessel should be insulated to avoid loss of heat. When an excess of oleum is employed, the sulphate is preeipitated by dilution with water, and the excess acid may be recovered.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK

Monday, May 2.

Royal Institution, 5. (Annual Meeting).
Society of Chemical Industry, 8. (At London).

Tuesday, May 3.

Royal Institution, 3. "Darwin's Theory of Man's Origin" by Prof. A. Keith.
Röntgen Society, 8.15.
Royal Society of Arts, 4.30.

Wednesday, May 4.

Royal Society of Arts, 4.30.
Institute of Metals, 8.
Society of Public Analysts, 8. "Detection and Estimation of Illipé Nut Fat used as a substitute for Cocoa Butter" by Francis G. H. Tate and John W. Pooley. "Notes and Demonstration on Apparatus for determining Hydrogen ion concentration" by G. W Monier Williams. "A Note on the Oil of Oats" by Ernest Paul. "Estimation of Potassium in presence of Sodium, Magnesium, Sulphates and Phosphates" by H. Atkinson.

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Thursday, May 5.

Royal Institution, 3. "Psychological Studies—The Localisation of Sound" by Dr. C. S. Myers.
Institution of Electrical Engineers, 6.
Chemical Society, 8.

Friday, May 6.

Royal Institution, 9. "War Developments of Explosives" by Sir Robert Robertson.
Society of Chemical Industry, 7. (At Manchester).

Saturday, May 7.

Royal Institution, 3. "Chemical Reaction" by Prof. E. C. C. Baly.

UNIVERSITY OF LONDON.

A COURSE of Two Lectures on "THE METASTABILITY OF MATTER AND ITS BEARING ON CHEMISTRY AND PHYSICS," will be given in English by Professor ERNST COHEN, Professor of Chemistry in the *University of Utrecht*, at *UNIVERSITY COLLEGE, Gower Street*, W.C., at 5.30 p.m. on TUESDAY, MAY 10th and THURSDAY, MAY 12th. The Chair at the first Lecture will be taken by Professor F. G. Donnan, C.B.E., F.R.S., Professor of Chemistry in the University, and at the second Lecture by Dr. George Senter, D.Sc., Ph.D., F.I.C., Principal of Birkbeck College. The Lectures are addressed to students of the University and others interested in the subject. ADMISSION FREE, WITHOUT TICKET.

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THE CHEMICAL NEWS.
VOL. CXXII., No. 3186.

THE COLOUR AND MOLECULAR FORMULA OF WATER AND ICE.

By E. TOMKINSON.

Part I.

IN connection with Prof. W. D. Bancroft's recent paper on this subject, the following notes may be of interest (see CHEMICAL NEWS, 1919, cxviii., 197, 208, 222, 233, 248, 254; and 1921, cxxii., 9, 34). (*Note.*—Rayleigh's work on He and Ar is noticed in the CHEMICAL NEWS, 1920, cxxi., 248, *c.f. Nature*, 1920, p. 584).

Prof. W. Spring, at the 5th International Congress of Hydrology, Climatology, and Medical Geology, Liège, October, *1898*, delivered an address on the colours of natural waters, in which he states that, when pure water has a very slight cloudiness, due to the presence of finely-divided nearly white or colourless particles. Even if these are absolutely colourless, as in the case of very finely-divided rock crystal, a yellow tint is given to the water, which, *together with the natural blue proper to the water itself,* produces a green colour, as in the cases of the Lakes of Neuchatel and of Constance (*c.f.* other explanations, Bancroft, *loc. cit.*). The usually green colour of certain lakes occasionally becomes absolutely colourless, which is due to the washing into the lakes of a fine mud of a reddish tint (iron oxide); which neutralises the green colour, rendering it for the time being perfectly colourless.

A rather different aspect of the question was brought forward by the work of Threlfall (Richard Threlfall, *Nature*, 1899, lix., 461), thus: "During a recent voyage by the Messageries steamer "Polynesien," I was permitted, through the kindness of Commandant Bullard, to erect a tube 736 cm. long against the rail of the afterdeck, and to pass through it a continuous stream of water from the ship's salt-water service. The water was taken in well forward, and at a depth of two or three metres, and consequently was not soiled by the passage of the ship. I made a series of observations with the apparatus described, matching the colour of the sea-water by making mixtures of definite substances and using these mixtures to fill a tube 18 cm. long, placed alongside the water tube.

"Both tubes were illuminated by diffused daylight reflected from a white screen, and by the aid of diaphragms, etc., it was arranged so that the angular area of the visible part of the screen was the same whether observed through one tube or the other. Observations were made every day on the voyage from Sydney to Marseilles, but owing to the uncertainty arising from the contamination of the water by the varnish with which the interior of the tube was protected, it is useless to comment on most of the results obtained, except in so far as they give a means of easily reproducing the exact tint of pure sea-water as seen through a column 736 cm. long.

"Make up the following solution: water 500 cc., soluble Prussian blue, 0·001 grm., saturated limewater, just precipitated by the smallest excess of bicarbonate of soda, 5 cc. This mixture when when viewed through a tube 18 cm. long, will show with considerable precision the colour of a sample of water from the Mediterranean, lat. 36 deg 24min. N., long. 17 deg. 51 min. E. (of Paris). By using various lengths of tubes I found that when a match has once been made, it can be preserved (within the limits tested) by increasing the amount of Prussian blue proportionally to the length of the column of water under consideration.

"In these tests I made use of tubes 183 cm. long, which could be mounted in series; the relation held as the number of tubes was increased from two to five. I consider that it would be worth while for a series of measurements to be made systematically by this method, and therefore mention that the tubes must be of black porcelain or glass; the water must be pumped by the observer's private pump (which must be worked off the electric service), and must give a pressure large enough for a Berkefield filter. The colour of daylight is also too variable on the deck of a ship protected by awnings, and a form of artificial illumination should be employed.

"In making the colour matches, it is best to arrange to look down the two tubes simultaneously, using one eye for each tube. By slight squinting, it is easy to get the sensation of two patches of colour on the screen side by side.

"The majority of the samples of water examined by me took 25 per cent less blue to match them than the sample quoted, and when the water was soiled by the tube, and perhaps at other times, it was necessary to add an amount of picric acid to a large proportion of the Prussian blue, and of course, giving a green solution. The transparency of the water is estimated by the amount of precipitated chalk it is necessary to add. At the same time, I am not sure that the loss of light observed, and requiring the addition to the match, is produced by turbidity. It is just as likely that the absorption spectrum of water is crossed by a faint but uniform band from end to end. In this case, a black liquid might be added to make the match, but I do not know of one which is anything like black in very dilute solution; of definite materials the best was the aniline dye sold under the name of steel-grey, but it was very distinctly purple.

"The water on the West and South-West coast of Western Australia is perhaps more interesting than any I have seen, for it is very green indeed, and very clear; so much so as to raise a doubt of the adequacy of Aitken's explanation (*Proc. Roy. Soc. Edin.*, 1882, ii., 472; see also Bancroft, *loc. cit.*), especially as the sand looks white rather than yellow. It is just possible that the sea may in certain places dissolve a sufficiency of yellow colouring matter from living or dead sea-weed to account for the green tint. All the observations I made convinced me that the possible scattering of light by very fine particles in suspension has got nothing to do with the colour of the sea-water."

In reply to the above (*Nature*, 1899, lix., 509), Aitken points out that he never stated that the yellow particles are the exclusive cause of the greenness in sea-waters, and concludes (p. 510): "As the waters of most of our rivers are yellowish brown, it is probable that it is the addition of this yellowish water to sea-water that makes the seas

surrounding our islands of a greenish colour"; but such an explanation obviously does not apply in the case of the Australian water described by Threlfall.

In Threlfall's paper, reference is made to the absorption spectrum of water. Hartley and Huntington (*Phil. Trans.*, 1879, clxx., 257), using the spark spectrum of an alloy of tin, lead, cadmium, and bismuth, found that water is quite diactinic transmitting all the rays as far as $\lambda = 2000$ Å.U. On the other hand, Colley (A. R. Colley, *Journ. Russ. Phys. Chem. Soc.*, xxxviii., 431; xxxix., 210) found that absorption bands occur in the optical and electrical spectra of water.

Water vapour, however, shows absorption in the infra-red; for example, the "a" 7165 absorption band, no bands occur for wave lengths of less than $\lambda = 5884$ Å.U. It was by the "a" band that the presence of water-vapour was detected on Mars (see Rolston, *Nature*, 1907, lxxvii., 442; Slipher, *ibid.*, 497; Lowell, *ibid.*, 503, 606; Campbell, *ibid.*, lxxxiv., 317).

A dark line or band in the spectrum of water has been reported (T. W. Backhouse, *Nature*, 1910, lxxxiv., 530) at $\lambda = 6000$ Å.U. approximately, occurring in buish-green fresh water and in sea-water. This line would tend to make water blue, but its effect is masked by strong general absorption in the whole of the red and orange beyond this dark line. In sea-water, this general absorption was found to extend more feebly to the D line of the solar spectrum, and even to the dry air band δ. The deep green of Lago Maggiore gave an almost identical line. This line was not found in the water of Lake Geneva, noted for its deep blueness, but the general absorption at the red end of the spectrum was very striking. Backhouse states that the bluest water is at Lago di Gonda, and the Blane See, near Handersteg. At the former place, the blue colour of the water was slightly tinged with green, but was often bluer than the bluest sky.

Sir E. Ray Lankester (*Nature*, 1910, lxxxiii., 68) drew attention to the beautiful light-blue colour of the water in storage tanks which had been treated for hardness by Clark's process, the colour being independent of the condition of the sky, and visible at (almost) any angle of vision. He also noticed that the white porcelain of a bath appeared distinctly blue with a layer of water 20ins. high in strong sunlight, the intensity of colour varying with the movement of the water in waves or ripples.

It has been shown (H. T. Barnes, *Nature*, 1910, lxxxiii., 188) that the rich blue colour of the hard clear ice at Glacier, B.C. persists even with small pieces of the ice; and surface ice, which has been slowly formed by conduction, and taken out of the St. Lawrence River, shows the same effect—but the block loses its colour after long exposure to light, and very rapidly in sunlight. Coloured sediment and air-cavities detract from the colour. Barnes attributed this colour to a "real absorption effect due to the large molecular aggregates, which absorb the long rays, and not a "blue-sky" effect. Sea-water is particularly blue, and here we have the added effect of salt molecules (in addition to which the water of the sea is very clear). W. H. Skerzer (Smithsonian Report, 1907) showed that the blue colour of the water and ice of the Canadian Rockies is a real absorption effect, the blue colour being increased by the presence of minute white sediment but not by coloured sediment." He refers to the analogy of the beautiful blue colour of liquid air as soon as most of the nitrogen has boiled away (due to the formation of complex oxygen molecules), and notes that the variations of specific heat, density, viscosity, and compressibility of water with temperature are due to gradual diminution of the molecular aggregates. It will be noted that this suggestion is in agreement with that advanced by J. Duclaux and Mme. E. Wollmann (*Journ. Physique*, 1912, (v), ii., 263—see Chemical News, 1921, cxxii., 9, 34).

W. N. Hartley (*Nature*, 1910, lxxxiii., 487) found that optically pure water cannot be prepared by distillation, even by first distilling with acid permanganate, and then re-distilling from a copper vessel into a receiver placed in a hydrogen atmosphere (which latter provides an optically pure atmosphere), but pure (optically) water was prepared by Tyndall by melting clear block ice in a vacuum, and this water was blue when viewed through a tube 3ft. in length. Prof. Hartley stated that it is only possible to observe the beautiful blue colour of the water at Fairy Loch beside Loch Lomond, being where it wells up from a fissure in the rock and passes over a vein of milk-white quartzite. In another instance, the blue colour was only observed when a white object was placed in the water. Hartley's explanation is that the blue is wholly due to absorption of rays of complementary colour; because, if not, the reflection of the blue rays by suspended fine particles should be seen against a dark ground on looking into the water, but this was found not to be the case. Against this we know that the light escaping reflection has a reddish-golden colour. He concludes: "In a hazy atmosphere when the sun is low and we look towards it we seen the golden colour; in the opposite direction we see the blue opalescence. The white light from the sky traversed the (last-mentioned) water in two directions to the bottom, and then, by reflection, back again, and it is safe to say that these two opposite colours would neutralise each other." (The water when undisturbed on the surface was almost invisible, but the bottom of the pool was composed of red stone.—E.T.).

A very interesting account of observations made on the "Challenger" and at other times is given by J. Y. Buchanan (*Nature*, 1910, lxxxiv., 87). He states that the green colour of the Antarctic water is due to the abundance of diatoms, and to a greater extent, to the excretions of animals for the subsistence of which the diatoms furnish the ultimate food supply. He says that the three colours of the ocean are ultramarine and indigo and the above green, and very properly notes that for the correct observation of the colour the greatest amount of light must reach the eye after passing through the water, and the least after reflection. By observation through the "screw-well" of the "Challenger," he was convinced that the water contained in its own mass sufficient colour to account for all that was perceived. As a result of experiments in the mid-Pacific, he concluded that the length of the uninterrupted column of (sea) water which transmits the more intense colour (pure but pale ultramarine) must be many times greater than 25 fathoms. He showed that the green colour of the sea-water at Mogador is

due to altered chlorophyll (see also W. N. Hartley, "Deep-Sea Chlorophyll," *Proc. Roy Soc. Edin.*, 1885, xiii., 130); and similarly for the water from Valparaiso to San Francisco.

Prof. Bancroft (*loc. cit.*) referred to the possible analogy between the colour of the blue sky and that of water. Lord Rayleigh has recently shown that the former is due to scattering of light by suspended particles (Friday Evening Discourse, Royal Institution, May 8, 1920; *Nature*, 1920, cv., 584). He has shown that light from the blue sky is polarised (when examined at right angles to the sun), just as is the blue light produced by scattering by particles of sulphur formed by addition of acid to a solution of sodium thiosulphate, the laterally scattered light in the last case corresponding to that of the blue sky, and the transmitted yellow light corresponding to that of the setting sun. The theory that the colour of the blue sky is due to the absorptive effect of ozone does not account for this polarisation (p. 586). It is of interest to note that the light from the night sky shows very little polarisation (compare Rayleigh, *Nature*, March 17, 1921). For Lord Rayleigh's recent work on the light scattered by gases in respect of polarisation, see the references given in the CHEMICAL NEWS, 1921, cxxii., 34; and also *Nature*, 1917-1918, and *Comptes Rendus*, 1920, clxxi., p. 1002, with reference to the work of Cabannes on the "Light Diffused by Argon").

Note.—The work by Dr. H. S. Hele-Shaw and others on the production of coloured bands by water in a state of tension may have some connection with the colour of water, but the subject is too complex to be entered into here (see *Nature*, 1898, lviii., 34, 520, 535; Osborne Reynolds, *ibid.* 467; Hele-Shaw, *ibid*, 1899, lix.; *Rep. Brit. Assoc.* 1898; and for later developments, C. J. Coker, *Engineering*, 1921, cxi., 1; and also March 24 and 31, 1921).

The Molecular Formula of Water.

The molecular formula of water at 0° corresponds to $(H_2O)_4$, according to the surface tension method of Eötvos (Ramsay and Shields, *Zeitschr. physikal Chem.*, 1893, xii., 433; *Phil. Trans.*, 1893, A, 662; *Zeitschr. physikal Chem.*, 1893, xii., 464; and the "Molecular Complexity of Liquids," *Journ. Chem. Soc.*, 1893, lxiii., 1089). This is a high value for a liquid, and water has also a large dielectric constant, 77 at 18°, in which, however, it is exceeded by liquid hydrocyanic acid (*Zeitschr. physikal Chem.*, 1902, xxxix., 217), H_2O_2, and formamide (Walden, *Trans. Far. Soc.*, 1910).

The dissociation of water increases with rise in temperature (Noyes, Carnegie Institution of Washington, Monograph No. 63) and this is explained (by Holmes) because water at low temperatures contains only a few molecules of H_2O, most of the molecules being polymerised; with rising temperatures these molecular complexes break down into simple molecules H_2O, of which the number in water is rapidly increasing with rising temperature. It is quite possible that whilst the percentage of H_2O molecules actually dissociated into ions, like other substances, decreases with rise in temperature, the concentration of the ions in pure water would increase until a large part of the polymerised water molecules had broken down into the simpler molecules, which only occurs at a comparatively high temperature.

Ramsay and Shields (*loc. cit.*) found the value of the association for water at its boiling point to be 2·66; whilst P. A. Guye (on the "Nature of Molecular Associations in the Special Case of Water," *Trans. Far. Soc.*, 1910, vi., 84) found the value 1·96, which, however, agrees with other determinations. Bousfield (*ibid*) pointed out that if this value were accepted, Sutherland's theory that liquid water is a mixture of di- and tri-hydrols becomes untenable, because if water is associated above 100°, monohydrol must exist in considerable amounts to lower the average association value to less than 2. I do not see how this follows—the monohydrol might quite conceivably be produced by decomposition of di-and tri-hydrols with rising temperature (0° → 100°+); but, in any case, Guye's values are uncorrected for equation of state (see Kendall, CHEMICAL NEWS, 1921, cxxii., 32).

T. M. Lowry and W. A. Bousfield (*Trans. Far. Soc.*, 1910, vi.) have proved that it is absolutely necessary to assume the existence of mono-, di-, and trihydrols in order to account for these complex changes and those occurring with solutions in water.

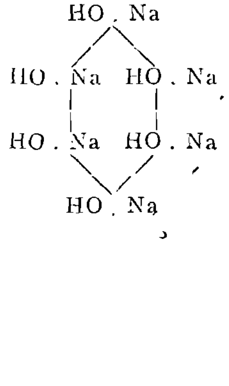
Sutherland (*Trans. Far. Soc.*, 1910, vi.) suggested that the hexagonal symmetry of ice crystals as evidence in favour of the trihydrol formula (for ice). He calculates the following densities:—

	Density. Solid.	Liquid.
Monohydrol, H_2O	1·37	1·26
Dihydrol $(H_2O)_2$	1·13	1·09
Trihydrol, $(H_2O)_3$	0·92	0·88

and considers that monohydrol is not present in liquid water, but is present in all salts containing water of crystallisation.

The minima in the specific heat of steam under moderate pressures and of liquid water under moderate changes are attributed to the dissociation of complexes, which explanation also applies to the anomalous behaviour of water at 4°, its magnetic behaviour (*Comptes Rendus*, 1912), and the variation in viscosity and compressibility of water with temperature changes.

F. P. Sexton (*Trans. Far. Soc.*, 1910, vi.) calculated the specific heat of the first four molecules of water in $CuSO_4.5H_2O$ to be 0·499, and the fifth, 0·598. Senter (*ibid*) stated that, in compounds like $CuSO_4$.5aq. four molecules of water are probably definitely associated with the metallic atom, and the remainder perhaps attached to the molecule as a whole. This should be considered in connection with Mr. H. T. F. Rhodes' paper (CHEMICAL NEWS, 1921, cxxii., 85, 97), in which (p. 87), formula (A), accords with Senter. He also refers to Kohlrauch's ring formula for water (p. 86), which is probably in agreement with Sutherland's suggestion. According to this, sodium hydroxide should have the constitution



i.e., $(NaOH)_6$.

This would probably be determinable by surface tension measurements of liquid caustic soda. (See also Jackson, Chemical News, 1920, cxx., 80, for colour of $CuSO_4.H_2O$ and $CuSO_4.5H_2O$).

Mr. W. R. Fielding has now modified his theory of polymerisation in the solid state to conform with the view that ice at its melting point is $(H_2O)_3$, whereas he previously concluded it to be $(H_2O)_2$. Ramsay and Shields, however, determined it to be $(H_2O)_4$, whilst by X-ray analysis, it has recently been evaluated as $(H_2O)_2$ (D. M. Dennison, Chemical News, 1921, cxxii., 55). This latter value is a direct determination, and should, I think, be accepted.

From a consideration of the connection between association and dissociation, it has been concluded that non-associated liquids do not ionise substances dissolved in them; associated liquids do.

In conclusion, we may note the following investigations in this field: Armstrong, B.A. Rep., 1885, 962; Armstrong and Watson, *Proc. Roy Soc.*, 1907, A, lxxix., 579; Caldwell, *ibid*, 1906, A, lxxvi., 272; Whymper, *ibid*, 1907, A, lxxix., 576; lxxvi., 272; Whymper, *ibid.*, A, lxxxvii., 664; D. Berthelot, *Comptes Rendus*, 1900; and Porter, *Trans. Far. Soc.*, 1910, vi.

Finally, the theories as to the colour of water and ice may be thus grouped: (1) That the blue colour of pure water and ice is due to selective absorption of rays of complimentary colour, perhaps due to the molecular aggregation (Duclaux and Wollmann; H. T. Barnes; and also W Spring); (2) that the colour is due to scattering of light by suspended particles (Aitken, Abegg, &c.); (3) that the colour is due to a sky-effect; (4) that, in the case of sea-water, it is due to dissolved organic matter (Buchanan).

I think that (1) and (4) adequately explain all the observed facts.

6, Kitchener St., Walney,
Barrow-in-Furness.
4th April, 1921.

THE PRESENT POSITION OF CHEMISTRY AND CHEMISTS.*

By Prof. N. T. M. WILSMORE.

The tremendous events through which we have passed since the last meeting of the Australasian Association for the Advancement of Science have brought about changes in our social and economic conditions of so far-reaching a nature, that little apology is needed for attempting briefly to take stock of the resultant effect on the position of chemistry and chemists.

Many of the changes caused by the war are still in progress, whilst others are too recent to be viewed in their right perspective, so that with regard to most of them it is hardly possible as yet to decide which are for the better and which for the worse. Nevertheless, I think we have some ground for concluding that, on the whole, the effect of the war on the position of chemistry and chemists has been favourable. In any case, it has provided an object lesson of the national importance of chemistry, which the man in the street cannot afford to neglect. But much remains to be done before chemistry is generally recognised, as it should be, not only as an indispensable branch of exact knowledge, but also as one of the learned professions, not inferior in status, for example, to law, medicine, or engineering.

Prior to the war the status of science and scientists in the estimation of the Government and people of Britain, and of Australia, compared most unfavourably with that accorded to them on the Continent of Europe or in the United States of America; and in spite of the drastic lessons of the war, it is still far from satisfactory. It has been well said that the work of men of science like James Watt or Dalton or Faraday has done more to shape our modern social and economic life than any statesman or so-called "social reformer"—dare one, in this free country, even with bated breath, add "or Labour leader"?—who ever lived. Yet there is too much reason to doubt whether so much as five per cent of the elected representatives of the people in Britain or Australia could give an intelligent answer, if they were asked who Dalton or Faraday were, or what they did.

As Mr. H. G. Wells in his "Outline History of the World" so forcibly and clearly points out, the present cultural ascendancy of the European peoples does not necessarily prove their racial superiority over the peoples of Asia. This ascendancy dates back only some four hundred years, and is due primarily to the command over the forces of Nature, achieved by a relatively small number of devoted men of science. There is good reason to believe that amongst the Asiatic peoples men not inferior in ability, may be found, who, given suitable environment, might produce similar results. Already the Asiatic peoples are beginning to realise this possibility; and when their awakening is complete, the ascendancy of the European peoples may disappear as quickly as it arose. The progress made by Japan alone in one generation shows that our comfortable belief in the fundamental superiority of the European may be a dangerous delusion, and that any weakening in the pursuit of scientific knowledge means risk of losing our present lead, possibly for ever.

However, in Australia we may congratulate ourselves that some progress is being made. The Institute of Science and Industry has at last been put upon an apparently permanent basis, and has been voted an income of £15,000 per annum. Carping critics may say that for the task of co-ordinating and organising the application of exact knowledge to the industries of Australia this sum, in view of the depreciated value of our currency, is ludicrously inadequate. But on the other hand, it amounts to nearly one-third as much as the involuntary contribution which our grateful country is making to increases in Commonwealth Parliamentary salaries, so obviously science has no reasonable ground to complain.

The unsatisfactory status in British communities of science in general is unfortunately shared by chemistry and chemists. This does not mean that British chemists have to admit inferiority to those of other countries. Far from it On the contrary, they may justly claim that in the quality, and in proportion to their numbers, in the quantity also, of their contributions to knowledge, especially those of a pioneering nature, they need not fear comparison with the chemists of any other nation. Yet up to, and even after the outbreak

* Presidential Address, delivered before Section B (Chemistry) of the Australasian Association for the advancement of Science at the Meeting held in Melbourne.

of war, their efforts to secure adequate recognition of their science from manufacturers, Government, and people, were met for the most part with contemptuous indifference. Since chemistry includes the study of changes in matter and of the accompanying transformations of energy, there is scarcely any branch of productive activity which does not require some knowledge of chemical phenomena, and in which, therefore, the progressive developments of modern chemistry can safely be ignored. This truth, which is stated at the beginning of most elementary text-books on chemistry, is so familiar to chemists as to be commonplace. Yet the oft-recurring failure of others to appreciate it, and to make effective use of the chemical knowledge and skill available, had as its inevitable consequence that many of the British manufacturing industries, especially the more particularly chemical industries, were falling behind in the race for world supremacy; with the further consequence that we nearly lost the war, and with it our existence as a Great Power, possibly even as an independent nation.

Fortunately for us there were notable exceptions to the general rule. For example, in one of the most important branches of applied chemistry in Britain, namely the steel industry, intensive research and scientific control had been for years the general practice in many of the works, with the result that, when the crisis came, the industry was able to respond to the enormous and varied demands which were made upon it. Another instance of the value of chemical research and control is given by the history of Brunner, Mond & Co., who, in the words of Prof Donnan, revolutionised the British alkali industry by introducing the delicate equilibria and reactions of Solvay in place of the rough-and-tumble heroics of the older Le Blanc process. The same policy enabled this firm to give invaluable help to the British Government in connection with the manufacture of high explosives. After many months of war, the British War Office decided to follow the German and Austrian lead, by adopting in place of picric acid or pure T.N.T. for the bursting charge of high explosive shells the much cheaper but equally effective mixture known as "amatol" consisting of 80 per cent by weight of ammonium nitrate with only 20 per cent of T.N.T. The manufacture of ammonium nitrate had, therefore, to be developed on a very large scale, but owing to the great amount of data and experience on the application of the Phase Rule to the phenomena of solubility and crystallisation in connection with solutions of mixed salts, which they had been accumulating for many years, the research staff of Brunner, Mond & Co. were able rapidly to work out on a technical scale three extremely neat and efficient methods for this manufacture, starting in the one case from synthetic calcium nitrate, and in the other two from Chili nitre.

As examples of the estimation in which chemists have been held by Government officials, the following incidents are worth recalling. Early in 1915, when the demand for a vastly increased output of munitions of all kinds was becoming urgent, the War Office found itself obliged to increase the staff of the Research Department at Woolwich, and accordingly advertised for a number of research chemists. The qualifications required were a B.Sc. degree in chemistry, together with the Associateship of the Institute of Chemistry and experience in analytical work; and to chemists possessing these qualifications was offered the munificent salary of £2 0s. 0d. per week At the close of the same year the British House of Commons Recruiting Committee, in attempting to classify vocations according to utility for munition and other work at home, issued the statement that the classes of workers which could most readily be spared for service in the Army were *"navvies, tunnellers, and chemists!"* On which the late Sir William Ramsay commented in a letter to the Press that, although this estimate of the value of chemists was doubtless due to ignorance, the men responsible for it had thereby shown themselves unfit to be trusted with the destinies of the Empire. But in this connection Australian officialdom was not to be outdone, for about the same time the Victorian Department of Mines advertised for a chemist with a B.Sc. degree and a sound knowledge of chemical analysis, to take part in research work on the distillation of brown coal and similar important problems, at the princely salary of £72 per annum!

Official indifference to science in general, and chemistry in particular, has cost us dearly, both in blood and treasure. We know, for instance, that early in 1915 Germany was running short, not only of propellant explosives, but also of the particular raw materials, cotton and glycerin, required for making them. Yet, in spite of the repeated warnings of Sir William Ramsay and other eminent chemists, our blockade was so negligently enforced, that for the first 15 months of the war the importation into enemy countries of cotton and of fats and oils was allowed to go on almost unchecked. As an example of the kind of ignorant obstruction which chemists had to face, it will suffice to mention that a well-known technical chemist of my acquaintance, in the course of an interview on this subject with a high official of the War Office, was met by the reply that, if we stopped the importation of cotton-wool into Germany, the Germans would simply make their explosives from *sheep's wool* instead, and that there was therefore nothing to justify the risk which we should run of offending the United States! However, at last things began to move, for a little later we find the present Lord Chancellor (then Sir F. E. Smith), stating in the course of an argument in a contraband case before the Prize Court, that it had "just been discovered that glycerin could be made from lard." Although he was thus unconsciously celebrating the centenary of Chevreul's great discovery, it is perhaps better that the members of our "governing classes" should acquire scientific knowledge a little late than not at all. Unfortunately, by the time sufficient understanding of the elementary chemistry of explosives had penetrated the minds of the powers that be to induce them to make the blockade really effective, the chance for seriously hindering the German manufacture of propellant explosives was lost. During the respite so generously allowed them by the British Government, the German chemists had been able to develop a process for making from wood pulp a cellulose sufficiently pure and uniform to give a satisfactory propellant, thus making the German manufacture of explosives as independent of the importation of cotton as it had already been made of that of nitrates.

The exceptionally unsatisfactory status of chemistry in the British Empire may be ascribed to various causes. One of these, and one which still operates to our detriment, has been the British Pharmacy Act of 1867, which has been adopted in principle throughout the Empire. For the most part this Act was admirable, as it not only gave legal recognition to the ancient and honorable profession of pharmacy, but also provided the public with a much-needed safeguard against the unchecked sale and incompetent dispensing of drugs possessing poisonous properties. But unfortunately, it contained one provision which has led to a most serious misunderstanding in the mind of the British public concerning the proper meaning of the word "chemist", and the rightful status of the chemical profession, a misunderstanding which is not found in any other civilised country. This provision forbids anyone but a chemist as defined in the Act to describe himself as such unless he has been duly registered as a "*chemist and druggist*" or a "*pharmaceutical chemist.*" Thus, to quote the Historian of the Institute of Chemistry of Great Britain and Ireland, "the President of the Chemical Society of London cannot in strict law call himself by the name by which he is known throughout the civilised world without breaking the laws of his country." It is difficult to believe that such a provision could have been passed by any legislature which was not pitiably ignorant of modern science. I understand that it has been adopted in a peculiarly obnoxious form in the State of Victoria. This deplorable but legalised annexation of the generic name of "chemist" by the followers of a specialised branch of applied chemistry is an example of a form of legislation which is fortunately rare. In fact, the only case at all parallel which I can recall, was when, somewhere about 1880, the Parliament of New South Wales, at the instance of the late Sir Henry Parkes, sought to have the name of that colony changed to "Australia."

It is pleasing to note that in other respects the relations between pharmacists and non-pharmaceutical chemists have been generally friendly. In fact, the British Pharmaceutical Society gave valuable help to the Institute of Chemistry, when, in 1884 and 1885, the latter was applying for its Royal Charter of Incorporation. Also in the meantime, many pharmacists seem to be coming to the conclusion that the name "chemist" is of questionable advantage to them, now that the public has been forced to realise that there are other important species of chemists, who have nothing to do with the dispensing of drugs or the sale of poisons. The signs of the times are therefore looking favourable to some reciprocal arrangement between pharmacists and chemists, whereby the former might consent to renounce the terms "chemist and druggist" and "pharmaceutical chemist" in favour of "pharmacist" or "apothecary," provided that the latter assist them to secure a stiffening up of the Pharmacy Acts, so that the dispensing of any kind of medical prescription, whether containing a poison or not, by anyone but a properly qualified and registered pharmacist would be prohibited. Such an arrangement could, however, be carried through only gradually and cautiously, or unjustifiable hardship to the present holders of the vested interest in the titles "chemist and druggist" and "pharmaceutical chemist" would be caused. For example, any sudden demand to alter shop signs and labels would entail very serious cost. But the very fact that any such change must be slow requires that this matter should be taken up vigorously by responsible bodies of chemists without delay. In this connection, it is worth noting that friendly negotiations with the above end in view have been going on for some time in England between the Institute of Chemistry and the Pharmaceutical Society, with some promise of success.

Much of the indifference to science shown by the average layman, must, I fear, be ascribed to his school training. Although science teaching of a sort is becoming general in our secondary, and even to some extent in our primary schools, it is too often so unintelligent and perfunctory that to many pupils it probably does more harm than good. In British secondary schools the practice is extending of employing for the teaching of science subjects teachers who have gained a university degree, preferably with honours, in those subjects. In Australian schools, however, with some notable exceptions, the salaries offered are too low to attract science teachers of first-rate ability and adequate training. In other words, the teaching of science is frequently left to the type of teacher who is content to keep one page ahead of the pupil, and who is therefore unfitted to present the subject to the latter as a living thing, of fundamental importance in his daily life. Under such conditions, school science degenerates into a mere cramming of text-books, which, in accordance with the good old school precedent, seem to have been selected chiefly for their exceeding dryness, and the inevitable result follows, that the mention of science calls up in the pupil's mind a positive repugnance, instead of the interest which should stimulate him to pursue the subject further for himself. Sir Robert Hadfield has recently ascribed his early interest in science largely to that fascinating work, Pepper's "Playbook of Science," and in a humbler capacity I must make the same confession. In this and the companion volume, the "Playbook of Metals," which were not, and perhaps never could have been, school textbooks, Pepper developed the art of conveying exact information and sound scientific principles, and at the same time calling up a spirit of scientific romance which is peculiarly attractive to the average boy. Sir Robert Hadfield states that not long ago he presented several hundred copies of a modernised edition of the "Playbook of Science" to the elementary schools of Sheffield, with satisfactory results. It would be well if a little of the spirit of that book could be infused into school science textbooks generally. But it may be doubted whether any spirit of romance could survive the deadening influence of the examination system.

Scientific men as a body have suffered in the past from too much reluctance to push their claims to recognition. I do not mean that we ought to rush into a campaign of self-assertion; but there should be a happy medium, if we could only find it. In the first place, the frequent practice by scientific men of doing valuable work gratuitously for governments and other public bodies, although it may be clear evidence of a moral superiority, is bad business, and should be discontinued. In the estimation of governments

and the public, the value of scientific, as of other work, is a function of the price which they have to pay for it. The function is too complex for complete analysis, but this much is clear, that as the price paid for scientific work approaches zero, the value set upon that work by those who benefit from it also becomes zero, or even negative. Further, no other class of professional man is expected to work gratuitously for public bodies, and when scientific men do so, they have only themselves to blame if their modesty is regarded as a confession of professional inferiority. If scientific men do not stand together to uphold their just claims to adequate reward for their labours, they may be quite certain that neither Government nor public is going to lose any sleep on their account. That the matter is urgent is shown by the fact that quite a number of prominent chemists, whom I had hoped to see at this meeting, have written to say that they cannot afford the journey. If the effect of the high cost of living and travelling on men with fixed salaries is going to convert the Australia States into water-tight compartments, so far as men of science are concerned, the prospects of science in Australia are not encouraging.

On the technical and industrial side chemists have fared unfavourably in professional status as compared with engineers. The reasons for this are not far to seek. The products of the engineer's labour are usually of a permanent nature, and appeal to the eye as definite and concrete achievements. The business or financial man believes that he understands them, and to some extent appreciates the difficulties which have been overcome in their erection. Naturally, therefore, he respects the man who created them. Also the engineer during his training has usually seen something of the handling of labour, and has acquired sufficient knowledge of business to enable him to meet the purely business man on more or less equal terms. On the other hand, our hard-headed business man is apt to regard the chemist as either of doubtful utility or a suspicious character. So far as he can see, the chemist seems to be spending his time in juggling with invisible molecules and atoms and electrons, which, as a business man has put it, "are so small and insignificant that they haven't got any size to 'em"; and it is difficult to convince him that these insignificant things make up in numbers for what they lack in size, and that he who can control them will rule the world. It must be admitted that the training of the chemist has been largely to blame. More often than not he has had no chance during his training to get any insight into the handling of labour or into business methods, or the working of technical plant, so that he starts his works experience with a heavy handicap as compared with the engineer. Hence we so often find the management of a manufacturing concern, even when the processes involved are largely of a chemical nature, in the hands of purely business men, or at the most of engineers. In such cases the chemists, if employed at all, are reduced to the position of mere testers, and are discouraged from acquiring too much knowledge of the business, let alone offering suggestions or criticisms. The idea of a chemical research department is scouted as a costly fad, and the so-called "practical man," who in reality is usually the worst kind of hap-hazard theorist, reigns supreme. It is not surprising that chemical manufactures under such conditions tend towards stagnation. In fact, a business involving chemical processes cannot be run indefinitely on such lines with safety; sooner or later it must succumb to the competition of more progressive rivals. Experience has shown the great advantage to be derived from allowing the chemists to acquire a working knowledge of every detail of the business, and even to share in the management. Above all, facilites for research are essential, if progress combined with economy is to be ensured. It hardly ever happens that the working out of new processes or of improvements in existing processes is achieved without making mistakes. And it should be obvious, even to the purely business or financial man, that it is cheaper to make these unavoidable mistakes on a small scale in a research laboratory than on a large scale in the works.

(To be continued.)

NITROTARTARIC ACID.

By ARTHUR LACHMAN.

ALTHOUGH nitrotartaric acid is the raw material of the important dye tartrazine, it has not been the subject of much published work; it is, however, a very interesting substance. It was first prepared by Dessaignes (Dessaignes, *ibid.*, 1852, liv., 731), by dissolving tartaric acid in strong nitric acid, and adding sulphuric acid to the mixture. He found it a rather unstable compound, and described its decomposition products quite accurately, although he overlooked the most important one, viz., dioxy-tartaric acid. This reaction was discovered by Kekule (Kekule, *Ann.*, 1883, ccxxi., 245). Dihydroxy-tartaric acid behaves like a diketone, and it is a condensation product of this diketone with phenylhydrazine sulphonic acid which forms the dye tartrazine.

There would seem to be little doubt, from its method of preparation, that nitrotartaric acid is really what its name implies, viz., the nitric ester of tartaric acid; yet it is usually referred to with quotation marks around the "nitro," or as "the so-called nitrotartaric acid." Its actual relationship to tartaric acid could only be brought out by *reducing* agents, such as ammonium sulphide; other reagents gave either *dihydroxy*-tartaric acid, or its decomposition products. It was an open question, therefore, whether nitrotartaric acid is not really a derivative of dihydroxy-tartaric acid, and thus an oxidation product rather than an ester.

The Constitution of Nitrotartaric Acid.

It is very difficult to dehydrate nitrotartaric acid completely; if the material is left exposed to air, it slowly takes up more moisture, loses nitrous acid, and changes over to the dihydroxy acid. If the slightly moist nitro acid is stored in a stoppered vessel, on the other hand, the brownish fumes, which appear at first, soon vanish; and after an interval of several weeks, the bottle contains *nitric* acid fumes, and a hard crust which proves to be chiefly tartaric acid.

The hydrolysis of nitrotartaric acid into its original components may be hastened considerably. One and ninety-three hundredths grm ,

moistened with one drop of water in a test-tube, showed nitric fumes after four days; after six days, tartaric acid was determined by the Goldenberg method, and 1·07 grm. found, 89 per cent of the amount calculated. The same quantity of nitro acid was moistened with 1 cc. of strong nitric acid, containing 0·3 grm. of water (just sufficient for complete hydrolysis) when 1·12 grm. of tartaric acid was found, 94 per cent of the theoretical yield. The reaction in this latter case completed itself overnight.

The extent of this acid hydrolysis is strongly influenced by the proportion of water present. Thus, when 2·00 grm. of nitro acid was allowed to stand with 7 grm. of water and 2 grm. of nitric acid, only 0·15 grm. of tartaric acid was found, a 12 per cent yield, and when still larger proportions of water are used, only traces of tartaric acid make their appearance.

Tartaric acid is also produced by the action of a few drops of strong hydrochloric acid or of moderately diluted sulphuric acid. There is little doubt, therefore, that nitrotartaric acid is a true nitric ester in the presence of high concentrations of mineral acids.

Preparation and Properties of Nitrotartaric Acid.

Preparation.—To prepare nitrotartaric acid, it not necessary to use fuming nitric acid, as Dessaignes did. To 70 cc. of nitric acid (sp. gr. 1·42) add 50 grm. of *powdered* tartaric acid, and stir well. Add concentrated sulphuric acid (sp. gr. 1·83) slowly, with stirring, until the tartaric acid is all dissolved; then add the balance of the sulphuric acid (200 to 250 cc. in all). Allow the mixture to cool slowly for several hours. Filter off the excess of sulphuric acid on a Büchner funnel; ordinary filter paper may be used if moderate suction is applied. Stir the cake with about 300 grm. of ice until all lumps are broken up, and extract the mixture with ether. Wash the ether twice with small amounts of ice-water, and dry with calcium chloride for a short time. Evaporate the ether carefully on the water-bath until brown fumes begin to appear, then allow to evaporate spontaneously. The product, except for traces of water and dihydroxy-tartaric acid, is practically pure nitrotartaric acid. The yield is from 60 to 75 per cent.

Properties.—Nitrotartaric acid crystallises in soft, white needles, which interlace much like those of asbestos. It is quite soluble in water, very soluble in alcohol, amyl alcohol, acetone, ether; insoluble in ligroin, benzene, &c. If carefully dehydrated over lime or caustic soda, it seems to keep indefinitely in a perfectly dry atmosphere. As ordinarily obtained, it smells of nitrous acid; the perfectly dry acid is odourless. For analysis, the acid was dissolved in dry ether, and precipitated by benzene.

Alkalies act violently on nitrotartaric acid, even in very dilute or in alcoholic solution, with practically complete decomposition, as discussed below. It is, however, unexpectedly stable towards sodium carbonate, and on titration shows itself to be a dibasic acid.

Subs., 0·2949 : 0·1 *N* sodium carbonate sol., 24·8 cc. (Equivalent to 100·6 per cent nitrotartaric acid).

Working at 0°, a perfectly sharp end-point is obtained with methyl orange as indicator.

The strength of nitrotartaric acid is manifested by its action on calcium chloride when the latter is used to dry its ethereal solution. After several hours, the calcium chloride lumps are covered with a feathery mass, which after two days fills the entire liquid; the ether then contains nitrosyl chloride. The solid consists of a mixture of the calcium salts of nitrotartaric and dihydroxy-tartaric acids.

On careful evaporation of a concentrated solution of nitrotartaric acid in sodium carbonate, a solid sodium salt can be obtained, though in impure form. This salt, although extremely soluble, is not deliquescent. It seems to show an abnormal behaviour, which is still under investigation.

Moist nitrotartaric acid decomposes with some violence well below 100°; the perfectly dry substance, however, was heated in xylene to the boiling point of the latter, without change.

When solutions of nitrotartaric acid in water are allowed to stand, they soon turn blue, gases are given off, and much heat is evolved. If the temperature is kept under control by water cooling, the process lasts from one to two days. The gases consist at first of nitrogen trioxide; later they become colourless, and are composed of nitric oxide and carbon dioxide. The solution contains chiefly dihydroxy-tartaric acid, which may be precipitated by addition of sodium acetate, or carbonate as the very insoluble sodium dihydroxy-tartrate; it also contains tartronic and oxalic acids. The yield of sodium dihydroxy-tartrate is from 75 to 80 per cent.

Little or no *tartaric* acid is formed; the highest amount found in many different hydrolyses was 1·3 per cent of the possible yield; in a few cases its presence could not be shown by the Goldenberg method.

The formation of tartronic acid during the above-described hydrolysis is due to the decomposition of dihydroxy-tartaric acid, as shown previously by Kekule and by Gruber; the latter acid loses carbon dioxide and passes over into tartronic acid. The mechanism of this reaction is not clear, and it is now being investigated. The production of oxalic acid is due to a side reaction, viz., the oxidation of tartronic acid by nitrous acid,

$$C_3H_4O_5+4HNO_2=C_2H_2O_4+CO_2+3H_2O+4NO.$$

This was proved by slowly adding a solution of tartronic acid to sodium nitrite; a copious precipitate of sodium oxalate was obtained. Tartaric and dihydroxy-tartaric acids, treated similarly, gave no oxalic acid whatever.

The Action of Alkalies on Nitrotartaric Acid.

When nitrotartaric acid is neutralised with caustic soda, the action is accompanied by the immediate evolution of considerable heat. Regardless of dilution within ordinary limits, cooling to −5°, or use of alcohol as a solvent, the same results are obtained, viz., production of sodium nitrite in practically quantitative yield, and complete decomposition of the dihydroxy-tartaric acid. It is not necessary to give the experimental details of the numerous experiments that were made. Entirely similar results were noted when calcium hydroxide was employed. In place of dihydroxy-tartaric acid are found tartronic acid, as already noted by Skinner (Skinner, *J. Chem. Soc.*, 1898,

lxxiii., 488), and a considerable amount of oxalic acid. The latter probably owes its formation to intramolecular condensation of diketosuccinic acid, with simultaneous formation of glyoxalic acid.

$$COOH—CO—CO—COOH+H_2O = COOH—COOH+CHO—COOH.$$

This reaction is now being studied.

The identification and separation of mixtures of the various acids encountered is a difficult and tedious matter; tartronic and oxalic acids are particularly hard to separate quantitatively.

Discussion of Experimental Results.

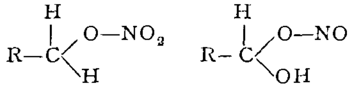
It has been shown that in the solid form, in the presence of strong acids, nitrotartaric acid is a true *nitrate* of tartaric acid. In aqueous solution, however, and when acted upon by alkalies, it behaves like a nitrite of dihydroxy-tartaric acid. The yield of dihydroxy-tartaric acid in the aqueous hydrolysis is good, considering the ease with which that acid is decomposed; and the yield of nitrous acid on hydrolysing with alkalies is almost quantitative. Nef (Nef, *Ann.*, 1899, cccix., 175), a number of years ago, showed that nitric esters of both fatty and aromatic alcohols yield considerable amounts of nitrous acid when saponified with alcoholic alkalies; the experimental conditions involved rather high concentrations of alkali, and the practical absence of water. In the present instance, the same reaction occurs in the complete absence of alkali, and in the presence of water. It may be taken for granted that the mechanism of the reaction is the same in both cases; nitrotartaric acid is an aggregation of strongly electro-negative components; benzyl nitrate becomes more electro-negative under the influence of alkalil.

The best explanation of the behaviour of nitrotartaric acid is that it passes over into a pseudo form as follows:

$$COOH—CH(ONO_2)—CH(ONO_2)—COOH \rightarrow COOH—C(OH)(ONO)—C(OH)(ONO)—COOH$$

This would appear to be a new type of tautomerism, involving the shifting of an oxygen atom instead of a hydrogen atom. The possibility of an hydroxyl group attached to nitrogen is excluded by the fact that nitrotartaric acid is only *di*basic; such a combination would almost certainly be strongly acid.

The suggested explanation of the formation of nitrous acid and a ketone in the case of nitrotartaric acid seems less forced than Nef's assumption of a "methylene dissociation" in the formation of nitrous acid and benzaldehyde from benzyl nitrate. It is much simpler to believe that benzyl nitrate isomerises to benzaldehyde nitrite,



which then loses NO—OH.

Nitroglycerin, like nitrotartaric acid, contains an accumulation of negative groups, and is therefore also sensitive to traces of acids, yielding nitrous acid and more or less complex aldehydes as first products, with rapidly increasing evolution of energy.

Owing to the comparative stability of dihydroxy-tartaric acid, it is possible to isolate it as the first product in the progressive decomposition of a nitric ester, and thus gain a clearer insight into the nature of explosive processes in general.

Summary.

1. Nitrotartaric acid is shown to be a true nitric ester of tartaric acid.

2. The decomposition of nitrotartaric acid in aqueous and in alkaline solution has been studied. The acid behaves as if it were the nitrous ester of dihydroxy-tartaric acid.

3. Nitrotartaric acid probably exists in two tautomeric forms, characterised by the shifting of an oxygen atom.

4. The decomposition of other nitric esters, such as nitroglycerin, is analogous to the behaviour of nitrotartaric acid.—*Journal of the American Chemical Society*, March, 1921.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, April 14, 1921.

PROF. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read:—

"*Influence of Low Temperatures on the Magnetic Properties of Alloys of Iron with Nickel and Manganese.*" By Prof. K. ONNES, For. Mem. R.S., Sir R. HADFIELD, F.R.S., and Dr. H. R. WOLTJER.

1. A series of iron-manganese and iron-nickel alloys with a range of percentages of manganese and nickel respectively has been tested in order to investigate the influence of cooling to very low temperatures (liquid hydrogen and liquid helium) on their magnetic properties, especially to ascertain whether the iron-manganese alloys which are non-magnetic at atmospheric temperature become magnetic by so doing.

2. With a view to the desirability not only after, but also during immersion in liquid hydrogen, an apparatus has been constructed, which makes it possible to test the samples quickly one after another at a temperature of 20° K., with as little loss of hydrogen as possible.

3. The iron-manganese alloys, containing the higher percentages of manganese, cannot be made magnetic at atmospheric temperature by cooling to the boiling point of liquid hydrogen or liquid helium.

4. The existence of one magnetic and one non-magnetic, or at most slightly magnetic, manganese-iron compound is shown to be probable, and the non-magnetic properties of the higher manganese-iron alloys may be explained by their means.

"*Influence of Physical Conditions on the Velocity of Decomposition of Certain Crystalline Solids.*" By C. N. HINSHELWOOD and E. J. BOWEN.

Experiments have been performed on the velocity of decomposition by heat of certain crystalline solids, such as potassium permanganate and ammonium bichromate. While in the case of liquid and gaseous systems the temperature coefficient of the reaction velocity allows calculation of a

"heat of activation" or "critical increment" of the reacting molecule, according to the method of Trautz, Lewis, and others, this calculation is not possible in the case of solids for various physical reasons connected with the propagation of the reaction from the surface into the interior. These are discussed in detail. On the other hand, the lowering of the velocity of decomposition of potassium permanganate when brought into solid solution in potassium perchlorate, indicates that the heat of activation of the permanganate is increased by the physical process of solid mixture. By equating this assumed increase in the heat of activation to the observed heat of solid mixture (obtained from the calorimetric measurements of Sommerfeld), approximate quantitative agreement is found between the observed rates of decomposition of potassium permanganate in various solid solutions and those calculated.

"*Adsorption of Gas by Charcoal, Silica, and other Substances.*" By Prof. H. Briggs.

The method of determining the adsorptive capacity of a substance at liquid temperature is described, and results are given of the capacity and manner of preparation or occurrence of 36 substances.

Charcoal and silica are compared, especially as relates to nitrogen and hydrogen, to illustrate preferential adsorption, and the influence of chemical composition on gas adsorption is discussed.

The effect of the compressibility of the initial layer, when the density of an adsorbent is determined by the immersion method, is considered An evaluation is made of (*a*) the volume of solid matter, (*b*) that of the interstitial space between the granules, and (*c*) that of the internal gaseous space for silica and cocoanut charcoal.

The density of the nitrogen adsorbed at —190° C. by silica and charcoal is calculated from experimental data. From these results it becomes possible roughly to estimate the error affecting the density of charcoal ascertained from water-immersion, and it is concluded that that method gave a result, for the writer's cocoanut charcoal, which was at least 0·55 too high. The conditions affecting adsorption at low and high saturation are set forth.

The presence of capillaries is not sufficient to account for adsorption. A high-capacity silica may be deactivated, and in the inactive state it remains porous. Graphite, which has no pores, adsorbs gas at —190° C. The evidence leads to the conclusion that deactivated silica is vitreous It is argued that a vitreous solid, like a crystal, is a polymer, *i.e.*, a complete atomic linkage. The importance of distinguishing between the coarser capillaries or canals and the finer interpolymeral openings of an adsorbent is emphasised.

Activation is considered to be the effect of disrupting the solid polymers, and the means of accomplishing the partial depolymerisation of charcoal and silica is described.

"*The Properties and Molecular Structure of Thin Films of Palmitic Acid on Water.*"—Part I. By N. K. Adam.

The behaviour of films of palmitic acid on water has been investigated in detail to test Langmuir's views (1917). These have been confirmed and extended.

Films on water exhibit a resistance to lateral compression which is not shown by a clean surface of water. Resistance commences at 22×10^{-16} sq. cm. per molecule (for palmitic acid), and increases linearly with further reduction of area until the force is sufficient to buckle the film. Collapse then sets in, and no further increase of force is regularly found necessary to diminish the area to zero. A metastable condition of increased resistance to collapse may however occur.

The compression curves point to the resistance being due to repulsion between the insoluble molecules, arranged in a single layer on the surface, each molecule being attracted to the water by its carboxyl group. The view that films two molecules thick exist appears to be quite irreconcilable with the curves observed. When collapse of the unimolecular film occurs, the molecules ejected are seen to aggregate into fine lines many molecules in thickness.

The observed areas agree with the dimensions calculated from molecular volume studies, and the compressibility of the films is of the same order as for liquids in bulk.

The effect of acidity of the water on the films may be accounted for by the greater attraction of alkaline solutions than acid carboxyl groups. The observations indicate that the molecules are immersed further in alkaline than in acid solutions, even when alkalinity is insufficient to cause complete solution.

In still more alkaline solutions immersion becomes complete, and the molecules probably pass from the film into aggregates, having the hydrocarbon chains in the centre and the carboxyl groups on the surface. This structure is suggested for the "ionic micelle" of soap solutions.

"*On the Absorption of Light by Electrically Luminescent Mercury Vapour.*" By E. P. Metcalfe and B. Venkatesachar.

1. Experiments are described in which mercury vapour at low pressures, rendered luminous by the passage of small electric currents, is found to exert powerful selective absorption.

2. A list of wave-lengths found to be absorbed is given.

3. Photometric observations are recorded on the absorption and emission of 5461 A.U. by columns of mercury vapour of different lengths and carrying different surrents.

4. The relation between the ratio (emission/absorption) and the current density is found to be linear.

5. The lines 5461 A.U. and 4359 A.U. have been reversed so as to appear dark lines on the white-light spectrum of a carbon arc and of the sun.

6. The reversal of 5461 A.U. has been studied in detail with a Fabry and Perot étalon and with an échelon spectroscope.

NOTICES OF BOOKS.

"Physical and Chemical Constants and Some Mathematical Functions." By G. W. C. Kaye and T. H. Laby. Fourth Edition. London: Longmans, Green, & Co., Paternoster Row. Price 14s. net.

We are glad to find that in spite of the difficulties of production and of the numerous duties of

national importance that have fallen to the lot of at least one of the authors, it has been possible to revise and issue a fourth edition of this valuable work. The matter has been brought up to date. The chemical data has been recalculated on the basis of the International system of atomic weights. Among the additions to the book are tables of atomic numbers, X-ray wave-lengths, and terrestrial magnetic constants. The tables will naturally find a place in every laboratory. The size of the book is only slightly in excess of the last edition, and the design and binding is the same.

BOOKS RECEIVED.

"The Combined Chemical Dictionary." Compiled and Edited by the Editorial Staff of the Chemical Engineering Catalogue. First Edition, 1919. 487 Pages and Index. The Chemical Catalog Co., 19 Madison Avenue, New York.

"Ammonia and the Nitrides, with Special Reference to Their Synthesis." By Edward Maxted, Ph.D., B.Sc., F.C.S. With 16 Illustrations. lv.+116 Pages. London: J. & A. Churchill. Price 7s. 6d. net.

"Critical Microscopy: How to get the best out of the Microscope." By Alfred C. Coles, M.D., D.Sc. With 18 Illustrations. iv.+104 Pages. London: J. & A. Churchill. Price 7s. 6d. net.

"Inorganic Chemistry." By E. I. Lewis, M.A., D.Sc. With Introductory Note by Sir Richard Threlfall, K.C.B. xv.+432 Pages. Cambridge University Press. Price 9s. net.

"The Extra Pharmacopœia of Martindale and Westcott." Revised by W. Harrison Martindale, Ph.D., F.C.S. and W. Wynn Westcott, D.P.H. 17th Edition. Volume II. xx.+688 Pages. London: H. K. Lewis & Co., Ltd. Price 17s. 6d. net.

"Recent Practice in the Use of Self-Contained Breathing Apparatus." By Lieut. Rex C. Smart, M.C., R.E. xiii.+243 Pages. London: Charles Griffin & Co. Price 15s. net.

"Anthracene and Anthraquinone." By E. de Barry Barnett, B.Sc., F.I.C. xi.+435 Pages. London: Bailliere, Tindall, & Cox. Price 27s. 6d. net.

PAPERS RECEIVED.

"The Behaviour of Substances near the Absolute Zero." By William Rd. Fielding, M.A., M.Sc., Vict.

From the specific heats of lead, copper, &c., at very low temperatures the author has calculated their degrees of polymerisation at the absolute zero. The minimum values he obtains are: Pb_7, $(H_2O)_{36}$, and Cu_{150}. The polymericular weights at the absolute zero are then plotted against absolute melting points, and by interpolation he obtains values for many other substances. p (the degree of polymerisation) for the elements has a periodic value. Received April 18, 1921.

NOTES.

Physico-Chemical Problems Relating to the Soil.—The Faraday Society is organising a General Discussion on the above subject to take place during the afternoon and evening of May 31 next. The meeting will be held in the Rooms of the Chemical Society, London, and it will be presided over by Sir A. Daniel Hall, K.C.B., F.R.S., Chief Scientific Adviser to the Board of Agriculture. The Discussion will be opened by Dr. E. J. Russell, F.R.S., Director of the Rothamsted Experimental Station, who will give a general survey of the subject. A series of papers dealing with soil moisture, organic constituents, adsorption, and colloidal phenomena will then be put forward as a basis for discussion. It is expected that among those present will be Prof. Sven Oden, of the University of Upsala. Further particulars of the meeting may be obtained from the Secretary of the Faraday Society, 10, Essex Street, London, W.C.2.

Royal Institution.—At the Annual Meeting of the Members of the Royal Institution, held on the 2nd inst., Sir James Crichton-Browne, Treasurer and Vice-President, in the Chair, the Report of the Visitors for the year 1920, testifying to the continued prosperity and efficient management of the Institution, was read. The number of new Members elected during the year was 54, a slight decrease on the previous year. 63 Day Lectures and 19 Evening Discourses were delivered, and the books and pamphlets presented to the Library amounted to 163, and the number purchased by the Managers 465, making a total of 628 volumes added to the Library during the year. Thanks were voted to the President, Treasurer, and Secretary, to the Committees of Managers and Visitors, and the Professors, for their valuable services during the past year. The following were unanimously elected as Officers for the ensuing year: *President*—The Duke of Northumberland; *Treasurer*: Sir James Crichton-Browne; *Secretary*—Colonel E. H. Grove-Hills; *Managers*—The Rt. Hon. Lord Blyth, Horace T. Brown, J. H. Balfour Browne, John M. Bruce, Sir James J. Dobbie, Percy F. Frankland, Alexander H. Goschen, The Rt. Hon. Earl Iveagh, H. R. Kempe, Sir Ernest Moon, Alfred W. Porter, Sir James Reid, Bart., Sir David Salomons, Bart., Sir Alfred Yarrow, Bart., The Rt. Hon. Sir Robert Younger. *Visitors*—James H. Batty, Alfred Carpmael, Frank Clowes, Edward Dent, Lieut.-Col. Henry E. Gaulter, George H. Griffin, W. E. Lawson Johnston, John R. Leeson, F. K. McLean, Edward M. Nicholls, Hugh M. Ross, Joseph Shaw, Sidney Skinner, Thomas H. Sowerby, William Stone.

The Official Handbook of the British Association of Trade and Technical Journals has just been issued. The publications represented in the Membership of the Association number some 200, and embrace practically every class of industry. We note that engineering mechanics and electrical engineering exceed in number the publications of most of the other professions. The Handbook is convenient in size, and will certainly be useful, as it gives all the information as to date of issue, size price, advertisement rates, and particulars of all

the journals mentioned. The price of the Handbook is 1s., and the offices, Sicilian House, Southampton Row, London, W.C.1.

The Printing Trades' Exhibition at the Royal Agricultural Hall will continue open until May 14. The Exhibition is very complete, one feature being a two day's Discussion, at which a long list of subjects is arranged. We note with pleasure no "ex-enemy goods" are permitted. Tickets can be obtained at the offices, 30, Fleet Street, E.C.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

10792—Mirat, G.—Manufacture of sulphuric acid. April 13th.
11039—Peace, E. L.—Manufacture of compounds of ammonia, etc. April 15th.
10615—Plauson, H.—Manufacture and treatment of viscose. April 13th.
10771—Pistor, J.—Manufacture of stable compounds containing oxygen and calcium. April 13th.
10792—Piperaut, P.—Manufacture of sulphuric acid. April 13th.

Specifications published this Week.

161244—Douglas, R. P.—Method of means for use in the manufacture of ammonia.
161253—Paris, A. J.—Process of cleaning and refining petroleum and analogous distillates.
161273—Kelly, A.—Manufacture of acid sodium pyrophostes.
161310—Wildman H. G.—Process for the extraction of alumina and its salts from clay.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK

Monday, May 9.

Royal Institution, 5. (General Meeting).
Faraday Society, 8. "The Problem of the Fuel Cell" by E. K. Rideal and U. R. Evans. "The Solubility of Small Particles and the Stability of Colloids" by L. F. Knapp. "Note on a Formula Expressing the Variation of Surface Tension with Temperature" by Prof. F. G. Donnan. Studies in Capillarity—Continuation of Discussion held at Manchester on the following papers: Part I—"Some General Considerations and a Discussion of the Methods of Measuring Interfacial Tensions" by Allan Ferguson. Part II—"A Modification of the Capillary Tube Method for the Measurement of Surface Tensions" by Allan Ferguson and P. E. Dowson.

Tuesday, May 10.

Royal Institution, 3. "Darwin's Theory of Man's Origin" by Prof. A. Keith.
Institution of Petroleum Technologists, 5.30.

Wednesday, May 11.

Royal Society of Arts, 4.30.

Thursday, May 12.

Royal Society, 4.30. "The Problem of Finite Focal Depth revealed by Seismometers" by G. W. Walker. "A Liquid Oxygen Vapourizer" by E. A. Griffiths. "Some Experiments on the Catalytic Reduction of Ethylene to Ethane" by Dorothy M. Palmer and W. G. Palmer. "The Catalytic Activity of Copper" by W. G. Palmer. "The total Heat of Liquid Carbonic Acid" by Prof. J. F. Jenkin and D. N. Shorthose. "Viscosity and Molecular Dimensions of Gaseous Cyanogen" by A. O. Rankine.
Royal Institution, 3. "Psychological Studies—The Appreciation of Music" by Dr. C. S. Myers.
Institute of Chemistry. (At Liverpool).

Friday, May 13.

Royal Institution, 9. "The Determination of Sex" by Dr. W. Bateson.
Physical Society, 5

Saturday, May 14.

Royal Institution, 3. "Chemical Reaction" by Dr E. C. C. Baly

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the Editor.

SUBSCRIPTIONS, £1 12s. per annum, payable in advance, should be addressed to the Manager.

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UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE.

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Further particulars may be obtained from the undersigned, by whom 100 copies of applications and testimonials, (except for the last-named post for which three copies, which need not be printed, will suffice), must be received on or before May 28th, 1921.

D. J. A. BROWN,
Registrar.

University College, Cardiff.
April 22nd, 1921.

UNIVERSITY OF LONDON.

A COURSE of Two Lectures on "THE METASTABILITY OF MATTER AND ITS BEARING ON CHEMISTRY AND PHYSICS," will be given in English by Professor ERNST COHEN, Professor of Chemistry in the University of Utrecht, at UNIVERSITY COLLEGE, Gower Street, W.C., at 5.30 p.m. on TUESDAY, MAY 10th and THURSDAY, MAY 12th. The Chair at the first Lecture will be taken by Professor F. G. Donnan, C.B.E., F.R.S., Professor of Chemistry in the University, and at the second Lecture by Dr. George Senter, D.Sc., Ph.D., F.I.C., Principal of Birkbeck College. The Lectures are addressed to students of the University and others interested in the subject. ADMISSION FREE, WITHOUT TICKET.

EDWIN DELLER, Academic Registrar.

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THE CHEMICAL NEWS.
VOL. CXXII., No. 3187.

SOCIETY OF GLASS TECHNOLOGY.

THE Fourth Annual General Meeting of the Society of Glass Technology was held in the Chemistry Lecture Theatre, University College, Gower Street, London, on Wednesday, April 20, 1921, at 2.30 p.m.

The Secretary, Prof. W. E. S. TURNER, read a letter he had received from the late Lord Moulton's secretary. Lord Moulton, it was stated, "was looking forward to the dinner of your Society, but we can only regret that we all missed the inspiration which he would have given to your work in the future. He died, as he would wish to have died, in harness, but *we* can't help realising how necessary he was just now by reason of his great appreciation of England's scientific needs."

A number of amendments of the "Constitution and Rules" were approved, mainly with the object of making possible the election of honorary members. The Fourth Annual Report for the year 1920 was adopted. This showed that the total members on the roll at the end of 1920 was 620, 128 members having been elected during that year. The income and expenditure account showed a small deficit in the year's working. This was due to the increasing expense incurred in printing the *Journal*.

The following were then elected as officers of the Society in place of those retiring in accordance with the Society's rules:—

President—Morris W. Travers, D.Sc., F.I.C., F.R.S. (in place of S. N. Jenkinson, M.B.E.).

Vice-Presidents—Major W. L. Foster, C.B.E., D.S.O.; W. J. Rees, F.I.C.; F. Sweeting.

Members of Council—T. E. Barron; G. Wilson Clarke; F. E. Lamplough, M.A.; F. Lax; C. C. Paterson, O.B.E., M.I.C.E., M.I.E.E.

Treasurers—F. G. Clark (General); W. M. Clark, Ph.B. (American).

Secretary—Prof. W. E. S. Turner, O.B.E., D.Sc., M.Sc., F.Inst.P

Assistant Secretary—C. J. Peddle, M.B.E., D.Sc., F.I.C.

Auditors—Dennis Wood, F.S.A.A.; F. P. Wainwright.

A hearty vote of thanks accorded to the retiring officers was replied to by Mr. S. N. Jenkinson.

The new President, Dr. MORRIS W. TRAVERS, F.R.S., then delivered his Presidential Address on "*The Importance of Quantitative Investigation in Dealing with Technical Problems in the Glass Industry.*"

Before proceeding to the subject of his address he wished to pay tribute to the memory of two great men, whose names the place and occasion called to mind. He referred to Sir William Ramsay, under whom he was trained as a chemist, and upon whose staff in University College he had served for nine years. The discovery of argon, the starting point of Sir William Ramsay's greatest discoveries, was the outcome of accurate quantitative investigation. Lord Moulton, who was to have presided at the dinner that evening, when in charge of the Department of Explosive Supply, had insisted upon the observance of the principle that industrial processes must be based upon quantitative ivestigation, with the result that whenever his Deparment took over a factory it was almost invariably found possible to increase the efficiency of the processes carried out in it. His services to the country went far beyond the reorganisation of a great part of our chemical industry, and on the observance of the principles which he laid down depended, in a great measure, our success in the future.

Efficiency resulted from the economic use of money or credit, labour, materials, and energy, and was only possible when the losses under each heading could be accurately ascertained. The energy balance sheet was really as important as the financial balance sheet, and each should be drawn out with equal care. The position of the skilled accountant was clearly recognised, but, in most works, very little was known about the disposal of the energy, which was only dealt with in terms of tons of coal. It would be impossible to check waste of money if one merely kept account of gross receipts and expenditure. It was equally impossible to check waste of energy if one knew only the total fuel consumption in a furnace. Each furnace should be studied with a view to ascertaining whether unnecessary losses could be checked, the fuel consumption reduced, and the efficiency increased.

In a recent paper submitted to the Society the whole of the thermal and chemical changes taking place in a plant consisting of a steam-air blown gas producer, and a tank furnace melting soda lime bottle glass had been dealt with, and an attempt had been made to show how much of the total energy of the fuel could be utilised in melting the glass, upon what conditions the efficiency of the plant depended, and where losses occurred. The investigation had been carried out for his own information, and the results had surprised him, and also the members of the Society who were present when the paper was read. The work had also brought to light the fact that a great deal of fundamental work remained to be done before they could deal effectively with glass furnace problems. The investigation of the nature of gas-producer tar, its composition, heat of formation, and its influence on the efficiency of heat exchange in the furnace should be investigated. We also required certain information as to the actual temperatures of the gases as they entered and left furnaces. The thermochemistry of the melting and plaining of glass required further study.

Furnace design should be based upon quantitative knowledge of the laws which governed the flow of gases through channels and spaces. The outlet flues from a pot furnace were not made small in order *to keep the heat in the furnace*, but because the velocity of the gas through a flue of small section was necessarily high, and when the velocity of the outflow was high, comparatively large fluctuations in the pressure in the furnace induced relatively small changes in the rate of outflow. With small flues it was easier to maintain steady conditions than when the flues were large.

As an illustration of the value of quantitative investigation of furnace problems, he showed how it was possible to arrive at an estimate of the loss of heat through the crown of a tank furnace, and

of the relationship between the value of the heat saved per year and the cost of increasing the thickness of the crown of the furnace.

The study of the process of melting and plaining glass, and investigations bearing on the nature of the glass itself, offered a very wide field for research. Many facts suggested that glass in the *solid* condition resembled the elastic gels more closely than simple liquids. At a discussion at a meeting of the Faraday Society he had suggested that the discovery of Peters and Cragoe, of the American Bureau of Standards, of the abnormal expansion of glass in the neighbourhood of the softening temperature might lead to a parallel in the case of gels, the density of which was known to be considerably greater than the sum of the densities of their constituents. Experiments which he and Mr. Taffel had carried out confirmed this prediction, and they had embarked upon an investigation of the thermal properties of glass, hoping that the results might throw light on the nature of glass. He referred to other investigations bearing on this problem.

In conclusion, he dealt with functions of the scientific man and the practical man in industry, and the need for their co-operation in the solution of technical problems.

There followed a paper on "*Automatic Glass Feeding Devices*," by G. Dowse and E. Meigh, M.B.E., M.Sc. This paper was given by Mr. Meigh. It was illustrated by lantern slides and by a kinematograph film showing the Hartford-Fairmont feeder in operation with Lynch machines. It gave an informative survey of the development of the art of delivering molten glass automatically to forming machines. It dealt with the various patents chronologically in three main steps or periods: (a) up to 1900; (b) 1900-1914; (c) from 1914 onwards. It was stated that during the last period of development there had been a perfect deluge of patents granted for feeders. This sudden rush of invention was due to several causes. The semi-automatic machines had come into use in America, and the increasing shortage of boy labour led to the elimination of the transfer boy and the development of the "no-boy" machine. The gatherer was now the only human element left between the furnace and the taker-in, and it was a logical step to replace him by mechanism. The most advanced method of automatic feeding was on the "gob" principle (the "gob" being an embryo bottle or jar nicely calculated to suit the dimensions of the parison mould). This method was being developed to-day for sound physical reasons, and experience had already shown that "gob" feeding possessed considerable advantages over the cruder flow feeds of various types. Special reference was made to the Hartford-Fairmont system. In conclusion, it urged for far more serious attention to automatic feeding devices by British glass manufacturers anxious to advance the country's interests. It pointed out that the adopting of automatic processes converted glass manufacture from a small-scale, many-unit, skilled craftsman's constant personal triumph over miserably poor and inefficient equipment into an engineering enterprise of the first magnitude. Unfortunately, in Great Britain glass engineering problems had been so neglected, and the dearth of glass engineers was so painfully severe, that the industry could not rise to its opportunities. During the war, and since, giant strides had been made in the application of science and scientific methods to the glass industry, and this had resulted in the industry being left with a large balance of information which it was totally unable to digest and utilise commercially, because it was deficient in the knowledge of the technique of glass manufacture and lacked adequate engineering personnel. Sheffield University had provided for the industry the chemists and the physicists. Let it now take the opportunity in both hands and provide the glass engineers, for unless trained glass engineers were forthcoming, the introduction of automatic glass-making machinery into our glassworks could be quite abortive.

The Third Annual Dinner of the Society was held on Wednesday evening, April 20, at the Hotel Cecil, London. The President, Dr. M. W. Travers, presided. The guests included A. Chaston Chapman, F.R.S., President of the Institute of Chemistry, Prof. F. J. Cheshire, Imperial College of Science and Technology, Dennis Herbert, M.P., Wm. Ide, Master of the Glass Sellers' Company, and R. S. Whipple, President of the Optical Society.

Following the toast of "The King," the toast of "The Society of Glass Technology" was proposed by Mr. A. Chaston Chapman. In the course of his reply Dr. Travers referred to the legislation recently proposed by the Government for the protection of the scientific branch of the industry. The view that the tariffs suggested were unsuitable and inadequate was held not only by the manufacturers, but also by the scientific and industrial worlds dependent upon supplies of chemical glassware. The only assistance which would enable this particular branch of the industry to continue was the total prohibition of all chemical glassware except under licence. It was a matter of great regret that electric lamp bulbs had not been provided for in the bill. The war had shown how extremely important these articles were, and it was felt strongly that the Government should be made to realise the importance of the question. Such assistance should be provided as was necessary to enable the manufacture of electric lamp bulbs to be continued in this country.

Mr. Dennis Herbert, M.P., submitted the toast of "The Glass Industry." It was one of the industries that saved the country during the war; but it was now suffering from the unfair competition to which it was now subjected owing to the depreciation of the exchanges in Germany and Austria. He trusted that the assistance proposed by the Government would be of some use in alleviating the hardship of competition without opposing the economic laws too directly. The production of chemical and scientific glassware was a key industry. It should therefore be protected by absolutely forbidding the entry into this country of former enemy goods which would tend to destroy the maintenance and progress of the industry.

On the following day a party of some 50 members of the Society travelled to Greenford to inspect the newly-erected works of Messrs. Rockware Glass Syndicate, Ltd. Here they were met by Mr. J. H. O. Bunge and Mr. Ed. Meigh. A most instructive time was spent, of special interest being the Hartford-Fairmont feeders operating in conjunction with Lynch machines.

ATOMIC ENERGY AND RADIATION FROM THE SUN.

By F. H. LORING.

THE enormous output of radiant energy from the sun has been attributed to two causes, viz: (1) contraction of its mass, and (2) radioactive disintegration of its atoms. In the *Encyclopædia Britannica*, 1911, p. 88, a brief mention is made of these two causes of heat in the sun. It is stated that a source of heat which seems plausible "is rearrangement of the structure of the elements' atoms." So far as the present writer is aware, no connection between these two sources of energy has been suggested.

It is of course known that the heavier atoms of the Periodic Table exhibit radioactive properties; and in the case of the sun its mass is so great (see Table I.) that contraction would account for the emission of considerable radiant energy; but, in the latter case this energy has not been supposed to be sufficient to account for the enormous output of energy known to take place.

Looking at these matters from a general point of view, it would seem that in some way *pressure due to largeness of mass* might be a factor in both phenomena.

If one considers the atomic edifice to have a fixity of structure and a cohesive property which arises from the atomic electrons, positive and negative, so that the rigidity of matter and the definite atomic domains (Bragg) are due to the operation of electric and magnetic forces, as partly suggested by the Lewis-Langmuir atomic theory and the work and views of other physicists, then it becomes evident that these forces play a prominent part in giving to various atomic configurations or aggregations the observed physical properties of matter.

It is possible to show that these forces which give rise to both mechanically resistant and cohesive properties of matter are primarily due to what might be termed the kinetic state of the atomic constituents; in particular, to the negative electrons, which are presumably in rapid movement. Should the active systems resembling planetary systems be sufficiently disturbed, an outburst of energy from the atom might result; and, in the case of the radio-atoms, the energy of these systems appears as ejected particles, consisting of helium nuclei and negative electrons. If these ejected particles strike the atoms or molecules of a gas (in reality they probably pass more or less through them) ionisation results. M. N. Saha has studied the sun's spectrum from the point of view of ionisation potentials obtained in the laboratory. In the *Philosophical Magazine*, 1920, xl., pp. 472 and 809, Saha points out that the variations, as partly indicated by Table II., may be explained on the basis of a varying response of the elements to stimulation modified by the internal structure of the atom. All the known elements are supposed to be present in the sun, but they vary in response to ionising stimulation due to temperature. The enhanced lines are thought to be due to ionised atoms which are known to respond in a varying manner according to their ionisation potentials. Taking into account various ionisation potentials associated with different elements at different temperatures and pressures, calculations have been made which agree fairly well with the observed peculiarities. Referring to Table II., the data contained in columns (*e*) and (*f*) were not, of course, considered by Saha, as they are of very recent date.

Now in the case of the radio-atoms, largeness of mass appears to be associated with the phenomenon of radioactivity. It seems possible, therefore, that when the contraction due to mass is sufficiently great, the mechanisms of the atoms which give to them their "atomic domains" may cease to perform their normal functions; that is, cease in keeping the atomic constituents in their stable positions, and consequently, the systems may break up, and the energy of the component parts may appear as radiation. This is in general agreement with Bohr's theory, since in this case radiation is supposed to take place when the electron falls towards the nuclear part of the atom.

Therefore, the cause of radiant energy emission from the sun may be due primarily to the *pressure within its more central mass*, and the atoms suffering such a pressure may break up, or disintegrate; the internal kinetic energy of the atom being liberated as in radio-active phenomena. In fact, one could imagine the sun to be, as it were, a vast radioactive atom whose mass is so great that the forces of its ultimate parts become disturbed; and a radioactive process, the same as that of a disintegrating atom of radium, for example, takes place, thus giving rise to an enormous output of radiant energy. The solar atmosphere, or envelope, may be bombarded from within by nuclear particles and electrons from disintegrating atoms, which action produces gaseous ionisation.

If this idea be true, then it should be possible to induce radioactivity by subjecting atoms to enormous pressure. To produce artificially sufficient general pressure to cause atoms to disintegrate may not be physically possible. Sir E. Rutherford's experiments (see CHEMICAL NEWS, 1921, cxxii., 169) however, seem to be in harmony with this idea; for Rutherford has succeeded in breaking up the nitrogen atom by bombarding it with high-speed -particles. In the case of aluminium, the bombardment gave rise to the liberation of H-atoms, which had an energy 25 per cent greater than that of the incident α-particle. These experiments seem suggestive in this connection; for here is a case of an ordinary atom being artificially disintegrated by the blow or instantaneous pressure of the -particle ejected from radium C.

It might seem possible to trace a connection between the spectrum lines of the elements in the sun and the susceptibility of such elements to disintegration by the above method of Rutherford. The absence, for instance, of certain lines might be due to the elements having already been disintegrated by the radioactive change induced by the pressure leaving more of the less-breakable ones in evidence. This observation is supported by the absence of the spectrum of nitrogen, as this element is more easily broken up than some others. It is of possible interest to compare the data concerning certain elements in the sun and others apparently absent, as given by Saha (*loc. cit.*), with the behaviour of these elements bombarded with α-particles (Rutherford, *loc. cit.*). From Table II. it will be seen that there is just

such an agreement as one should expect, save for two or three exceptions, but any element present in the sun in great abundance might, obviously, account for discrepancies of the kind in question. *Solar physics* and *the structure of the atom* are really closely allied subjects, and great advances may be anticipated in these departments in the near future.

TABLE I.

Mass of the sun taking the earth as unity	329,390
Temperature of the sun's photosphere	7500° Abs.
Temperature of the sun's chromosphere	6000° Abs
Mean mass of the radio-atoms (H=1·00)	222
Mean mass of the radio-atoms taking an electron as unity about ...	404,000

TABLE II.

Elements not found in the sun. (a)	Elements of doubtful existence in the sun. (b)	Elements giving faint lines in the Fraunhofer spectrum. (c)	Elements which appear not to have been investigated as regards their presence in the sun. (d)	Elements whose atoms give long-range H-atoms under bombardment with α-particles from RaC. (e)	Elements whose atoms do not appear to be disintegrated by the α-particle bombardment; or which do not give long-range H-atoms on bombardment. (f)
B	Ne	K	F	B	He
N	Ar	Cu	Cl	N	Li
P	Kr	Zn	Br	F	Be
S	Xe	Ge	I	Na	C
As	Ru	Ag	Te	Al	O
Se	Ta	Cd	&c.	P	Mg
Rb	W	Sn			Si
Sb	Os	Pb	Ionised atoms of the high-level chromosphere.	Other elements known to exist in the sun.	S
Cs	Ir				Cl
Pr	Pt				K
Tl	Ra				Ca
Bi	Th		(g)	(h)	Ti
	U		Ca	He	Mn
			Sc	O	Fe
			Ti	Na	Cu
			Fe	Mg	Sn
			Sr	&c.	Au
			Ba		

Summary.

Saha's papers on ionisation in the sun afford some data as to the elements present therein, which together with (1) Rutherford's experiments in breaking up atoms by bombarding them with α-particles from RaC, and (2) the well-known fact that the radio-elements comprise atoms of greatest mass, and (3) the enormous mass of the sun, seem to suggest that the contraction of the sun's central mass forces atomic nuclei so close together that the constituents of atoms in rapid movement come into conflict, and an unstable state is impressed on them whereby radioactive disintegration takes place. Such a process should give rise to the bombardment of atoms in the envelope of the sun, and ionisation with radiation should ensue. Similarly, in the case of the radio-elements, their large mass may give rise to instability. A Table is prepared which shows that those elements from which Rutherford has obtained long-range H-atoms generally correspond to those elements not present in the sun; and, according to this hypothesis, they are the more disintegrable ones and they have in consequence been reduced in quantity by the above action, so that those remaining are the more resistant, except in one or two cases, which could be explained on the assumption that the elements in question are in greater abundance. Conversely, those elements the atoms of which seem to resist disintegration are more abundant in the sun. Solar physics and the structure of the atom are allied subjects, and great advances may be expected in these two important departments of science.

NOTE ON THE PREPARATION OF CHLORACETYL CHLORIDE.

By E. DE BARRY BARNETT, B.Sc., F.I.C.

CHLORACETYL chloride can be prepared by the chlorination of acetyl chloride (Jazukowitsch, *Zeit. f. Chem.*, *1868*, *234*; Wurtz, *Annales de Chimie* (3), xlix., 60), but the product obtained by this means almost always contains higher chlorinated substances such as dichloracetyl chloride. It can also be obtained by treating chloracetic acid at 100° C. with phosphorus trichloride, but the reaction is a violent one, and it is extremely difficult to obtain a product which is free from phosphorus. For this reason, Frankland and Patterson (*Trans. Chem. Soc.*, lxxix., 190) preferred to prepare the substance by treating a mixture of chloracetic acid and phosphorus pentoxide with anhydrous hydrochloric acid gas at 200° C., a process which has obvious disadvantages for use in the laboratory.

It has been shown by Heumann and Köchlin (*Ber.*, xvi., 1627) that in many cases carboxylic acids are readily converted into their chlorides by the action of thionyl chloride, and it has now been found that the action of thionyl chloride on chloracetic acid affords a very convenient method for the preparation of chloracetyl chloride. In pre paring acid chlorides by means of thionyl chloride, Heumann and Köchlin used excess of thionyl chloride, as owing to its low boiling point (78° C.) it was easy to remove excess by distillation. Chloracetyl chloride, however, has a compara tively low boiling-point, so that it is preferable to choose conditions such that the product still contains some unchanged chloracetic acid. Chlor acetic acid boils at 190°, and there is no difficulty in separating it from chloracetyl chloride by distillation.

The following method was found to give excellent results. 95 grms. of chloracetic acid and 130 grms. of thionyl chloride were placed in a flask provided with a reflux condenser and heated gently on the water-bath for two hours. Hydrochloric acid and sulphur dioxide were evolved, and the heating was so regulated that the evolution of gas was never very rapid. The end of the condenser was attached to a calcium chloride tube so as to prevent the absorption of atmospheric moisture. At the end of two hours the evolution of gas was very slow, and the contents of the flask were then boiled briskly over the flame until

it completely ceased, which was usually found to be the case at the end of about half-an-hour. The resulting liquid was then distilled and the fraction boiling at 100-110° C. collected. This weighed 85-90 grms. The residue in the flask weighed 20-25 grms., and consisted chiefly of unchanged chloracetic acid which crystallised on cooling. It was used together with more chloracetic acid for the preparation of further quantities of chloracetyl chloride, and by doing this, the total yield of chloracetyl chloride was found to reach 95 per cent of that theoretically possible.

In the literature (Beilstein, "Handbuch der organ. Chemie," 4th Ed., vol. iii., p. 199) the boiling point of chloracetyl chloride is given as "about 105° C." This figure seems to be a little too low. as 200 grms. of chloracetyl chloride prepared by the above method when distilled with a Young's 8-pear column passed over almost completely at 108-110° C. at 764 mm.

In the above preparation, technical chloracetic acid was used which was first purified by distillation and was found to boil constantly at 190° C. The crude product was yellow in colour, but the distilled acid was snow white. Technical thionyl chloride was also employed. It was purified by distillation with a Young's 12-pear column, and under these conditions passed over at 75-78° C.

THE PRESENT POSITION OF CHEMISTRY AND CHEMISTS.*

By Prof. N. T. M. WILSMORE.

(Continued from p. 211).

It is often contended, however, that the expense of a research department can be dispensed with, on the ground that a purely business and non-technical management can always call in expert knowledge when it needs it; but this is apt to be a sort of fool's paradise. In the first place, the purely business management may not know when expert advice is needed. In the second place, as I once ventured to point out to a gathering of business men, the wise choice of experts itself requires a certain amount of expert knowledge. In the estimation of the average layman, the claims of the real expert are apt to compare unfavourably with those of the quack, because the expert, having a reputation to lose, is unable to promise so much. Hence the quack will probably get the job. Instances where something like this has happened in connection, for example, with State enterprises, will probably be familiar to most of us.

The claim is still too often made, and received with approval, either explicitly or by implication, that the man who is ignorant of scientific or technical matters is for that reason specially fitted to take what is called a "broad view" of them, and therefore to control them. The view he takes will be "broad" enough, but at the same time, it will be found to be shallow and inaccurate, and the control which he exercises is usually pernicious. It may be admitted that the ultimate aim of every manufacturing business is to make money, and that the crucial test of every process used in that business is whether or not it will pay. Nevertheless, the experience of the past generation has shown repeatedly and conclusively that when the control of a manufacturing business becomes vested solely in the hands of financial men, the prosperity of that business is in danger. The successful chemical manufactures have been those in which chemists and engineers have had a share in the management, whilst those in which the exclusive control has been captured by finance have for the most part gone to the wall. The outstanding example is, of course, the history of the manufacture of synthetic dyes in Germany and Britain respectively.

The chemist must, however, beware of appearing to claim that in industrial matters he can supersede the business man. The successful conduct of a manufacturing business demands an intimate knowledge of buying and selling, and of finance, which the chemist has seldom had the opportunity or aptitude to acquire. The combination in the same individual of high scientific and technical attainment with acute business and financial capacity, although occasionally met with, is too rare to be counted as a normal factor in every-day practice. On the other hand, the dividing line between chemists and engineers is becoming less strongly marked. That growing and already important class of experts, the engineer chemists or chemical engineers, having a working knowledge of both chemistry and engineering, have shown themselves eminently fitted for such tasks as the planning of works and for positions of control. But in the nature of things, it is not possible for any engineer chemist to have a complete mastery of both branches, so that in the working out of details, and especially for research, he will frequently require the help of both chemists and engineers. Hence for the sound development of a manufacturing business involving chemical processes, we must look to collaboration on more or less equal terms between the chemist, the engineer, and the business man. Each of these classes should be represented on the Board of Directors, or its equivalent.

With the outbreak of the war came the great opportunity for British chemists to show what they could do, and to prove beyond question their indispensable value to the nation. The way in which they rose to this opportunity and the feats which they accomplished would, if they had been foretold in the previous time of peace, have been regarded by chemists themselves as a wild impossibility. In the manufacture of explosives, and still more in the development of counter measures, both defensive and offensive, against the newer methods of warfare introduced by the enemy, the chemist held the key to the position. Chemists were required for work which only they could do in every section of the war organisation; with the special chemists' corps in the front line, to direct anti-gas measures and gas attacks, and, incidentally to identify the various poisonous compounds which the enemy sent over; with the R.A.M.C., to supervise water supply, etc.; in the Navy, to direct the manufacture and use of artificial fog; in the various munition factories; in the Government and other research laboratories; and in other activities too numerous to mention. It would be untrue, as well as grossly unfair to other workers and especially to our fighting forces, to claim that chemists won the war. But we have every right to claim that, had it not been for the work of the British chemists, we should inevitably have lost it.

* Presidential Address, delivered before Section B (Chemistry), of the Australasian Association for the advancement of Science at the Meeting held in Melbourne.

There is every indication that unless the League of Nations becomes an effective restraining force, chemistry will play an even greater part in future wars than it has in the one we have just come through. This has already been recognised in the United States, where the Chemical Warfare Service has been organised as an independent branch of the Army. It would seem therefore, that except in wars against savage or semi-savage tribes, the days of the "dashing cavalry general" are over, and that he will have to be succeeded by one whose training has consisted largely of chemistry and engineering. If both sides are prepared for it, chemical warfare does not add so much to the horrors of war as the use of high-explosive shell. In 1918, the number of casualties in the British Army from poison, sufficiently severe to incapacitate a man for some weeks was unfortunately very large, yet the number of deaths therefrom was estimated not to have exceeded 4 per cent, whilst the percentage of deaths from gunshot wounds was between 20 and 30. The special infamy committed by the Germans lay in their taking deliberate advantage of a solemn covenant not to use poisons to spring a ghastly surprise on their opponents. The effect of that first chlorine attack in Flanders in May, 1915, was devastating, and had it been followed up, might well have been decisive. Apparently nothing prevented the Germans from marching through to the Channel Ports but the same kind of mental inertia and suspicion of new inventions on the part of the German professional officer, said to be characteristic of his British colleague.

When they began the war, the German High Command believed that the stocks of explosives and other munitions which they had previously been accumulating would be sufficient to enable them to override all opposition. Hence in Germany as with us, the manufacture of explosives was at first organised sufficiently to meet only peace-time requirements. But as soon as it was found that the Allies had developed an annoying capacity to hinder the war from proceeding according to plan, both sides were faced with the necessity to extend the manufacture of explosives on an unheard of scale. In this, however, the Germans started with the advantage greatly on their side. The enormous factories for the manufacture of dyes and other fine chemicals which had grown up in Germany were an invaluable asset, since the chemical plant which they contained could be converted rapidly to the purposes of explosives manufacture, and what is of some import at the present time, could as readily be re-converted to serve peace-time requirements. In Britain, on the other hand, the corresponding chemical resources were relatively small, so that we had to face the problem of erecting and equipping huge and entirely new factories, specially to meet the enormous demands suddenly made upon the nation. In response to these demands, there gradually arose that extraordinary organisation known as the Department of Explosives Supply of the Ministry of Munitions, with Lord Moulton as its Director-General. Lord Moulton's services to the nation have been frequently and justly extolled, but probably the greatest of them all was his selection for his Chief of Staff of Mr. K. B. Quinan, of the Cape Explosives Works. Mr. Quinan came from South Africa with an established reputation as an explosives expert and chemical engineer. When he returned thither at the close of the war he had proved himself to be one of the greatest organisers and men of genius who had fought in the Allied cause. Whilst he never spared himself, he possessed in a high degree the gift of winning the confidence and getting the very best out of those around him. It has happened to few men to receive such whole-hearted loyalty from colleagues and subordinates, and few have so well deserved it.

It was under Mr. Quinan in the Factories Branch of the Department of Explosives Supply that the British chemist found his greatest chance to come into his own. Starting from small beginnings in 1915, the Factories Branch gradually extended, until at the close of the war it controlled more than 20 factories, producing not only explosives, but also a great variety of other materials, including many of the so-called "poison gases." Many of these factories were designed by Mr. Quinan and erected under his supervision, and the management of all of them was subject to his control. Amongst the most noteworthy achievements were the great factory at Queen's Ferry, near Chester, capable of turning out over 800 tons per week of T.N.T., and over 200 tons per week of nitrocellulose, and the still larger factory at Gretna with a capacity of over 800 tons per week of finished cordite. Except that it obtained about half the necessary amount of nitrocellulose from Queen's Ferry, Gretna was self-contained, producing besides the balance of the nitrocellulose all the acids, ether and nitroglycerin it required. There was also a very large distilling plant for the refining of the crude glycerin.

Hand in hand with the erection of these factories had to go the training of the staffs to run them, and in this Mr. Quinan developed a two-fold purpose. The first consideration was of course to turn out the materials necessary for winning the war. (The possibility of losing it apparently did not trouble him). The second, however, was to make of the Department a great educational institution, and to give to the chemists and engineers who came under his influence such a thorough training in the erection and running of chemical plant and in all the details of factory management that they would be qualified to play their part in the great task of building up and extending the British chemical industries after the war was won. The methods by which these aims were accomplished are best described in Mr. Quinan's own words in the preface to the "Second Report on Costs and Efficiencies for H.M. Factories Controlled by the Factories Branch," dated September, 1918, and subsequently published by the Ministry of Munitions.

As was to be expected, the chemists showed themselves to be receptive pupils, and Mr. Quinan's educational policy met with complete success. The circulation of comparative costs data, combined with the frequent conferences between the staffs of the various factories and the Headquarters Staff of the Department, developed a spirit of emulation amongst the former, quite equal to that called up by severe trade competition. This, and the fact that they were provided with the very best plant obtainable, resulted in a smoothness and efficiency of working, which, all things considered, was little short of marvellous.

But the activities of the Department of Ex-

plosives Supply did not stop at explosives. Towards the end of 1917 orders were received to get out designs for a factory to produce about 30,000 tons per annum of synthetic ammonia for the immediate purpose of producing about 60,000 tons per annum of ammonium nitrate, but with the ultimate post-war object of making other ammonium compounds. After some two years' work, a team of ardent research chemists in the Munitions Inventions Department, including the late Dr. H. C. Greenwood, whose death about a year ago is so much to be deplored, had succeeded in reproducing the Haber process for the synthesis of ammonia on a large laboratory scale. The results which they had obtained were so promising, that Mr. Quinan decided to adopt the Haber process for the new factory. For war purposes, about half the ammonia so produced was to be oxidised by means of the Kühlmann catalytic process to nitric acid, which in turn was to be neutralised with the balance of the ammonia. Although the designs were partly completed, various causes, notably the necessity to concentrate on the manufacture of poisons, prevented rapid progress from being made with the factory itself; and when the Armistice was signed, all work on the latter was suspended. The project has, however, since been taken over by a syndicate formed by Brunner, Mond & Co., and it is to be hoped that, as a measure of national safety, it will be carried to completion.

The history of the Haber process affords one of the most striking illustrations of the truth, that the most far-reaching discoveries in the domain of applied science are often the result of research carried out, not with a definite technical aim, but solely from a desire to advance knowledge. The conditions for equilibrium between hydrogen, nitrogen, and ammonia possess very considerable physico-chemical interest; but in the early stages of Haber's researches thereon, commencing in 1905, it would have been difficult to find any chemical reaction which looked less likely to become of technical importance than the direct synthesis of ammonia from its elements. Even under high pressure and with the most active catalysts so far discovered, the temperature has to be pushed so high to obtain a sufficient rate of reaction, that equilibrium is reached when only comparatively small fractions of the hydrogen and nitrogen have combined. The suggestion that this unpromising reaction might be utilised for the manufacture of ammonia on a large scale was first made by Le Rossignol, a native of Jersey, who had been trained in Sir William Ramsay's laboratory in London, and had subsequently gone to work with Haber. Le Rossignol's proposal was to circulate the gases continuously under pressure through the catalyst furnace, a heat exchanger, an ammonia absorber, and again through the heat exchanger to the furnace. To test this suggestion a small laboratory plant was constructed by Haber and Le Rossignol, the working of which was so satisfactory that in 1909 the invention was taken over by the Badische Anilin und Sodafabrik. The difficulties in the way of constructing and running a large scale plant to work at about 600° C., and under a pressure of 150 to 200 atmospheres were considerable, but were successfully overcome. In 1917, the factory erected by the Badische Company at Oppau produced 93,000 tons of ammonia, reckoned as pure NH_3, by this process, whilst a second factory at Mersebürg, near Halle, has twice that capacity. Besides the Haber process, the Germans were also using the cyanamide process and the Pauling arc process for producing synthetic nitrogen compounds; but of the three the Haber process has proved itself to be the most economical and important. Had it not been for these processes, the Germans would have rapidly run short of nitrogen compounds both for agriculture and for the manufacture of munitions, and could hardly have survived one year of war. Perhaps this lesson is not entirely without interest for Australia.

(To be continued.)

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, April 21, 1921.

PROF. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read :—

"A Quantum Theory of Colour Vision." By PROF. J. JOLY, F.R.S.

According to the quantum theory of vision, the liberation of electrons in a sensitiser in the percipient layer of the retina is the source of vision, the energy values of the quanta proper to the three fundamental colours determining the sensation of colour.

In this paper the view is advanced that in accordance with the physiological law of nerve impulses, known as the "all-or-none" law, the cone is connected with the optic nerve through a plurality of nerve fibres; the rod being connected through one fibre only. This is supported by histological evidence.

The fundamental colour-sensations—red, green, and blue—may be taken as corresponding to frequencies in the ratio 2 : 3 : 4, and this is the ratio of the energies of the corresponding quanta and of the kinetic energies of the electrons liberated thereby. It is supposed that this is also the ratio of the numbers of fibres activated in the cone. In the case of the rod, quanta, in all cases, can activate but one fibre; hence its achromatic functions. In the case of the cone the activation of 2, 3, or 4 fibres evokes the fundamental sensations. White sensation arises when all nine fibres are activated.

The bearing of these views on the significance of the experimentally determined colour sensation curves and on colour blindness is considered. The energy relations of colour sensation and of luminous sensation are discussed.

"The Energy involved in the Electric Change in Muscle and Nerve." By Prof. A. V. HILL, F.R.S.

An expression is given for the heating effect, in a muscle or nerve, of the currents produced by the electric response accompanying the propagated impulse. In a muscle the heat produced is not more than one hundred thousandth part of the energy liberated in a twitch; in a nerve it of the order of size of $3 \cdot 5 \times 10^{-10}$ calorie or $0 \cdot 15$ erg. per

grm. It is concluded from the smallness of these quantities, that no appreciable provision of energy is required in the propagation of the electric response, and that the physico-chemical change producing the response is the only factor involved in the propagated nervous impulse.

"Asymmetry, Metamorphosis, and Origin of Flat-Fishes." By H. M. Kyle.

The flat-fishes owe their change of form in the beginning to an inherent asymmetry of the abdominal organs, the coil of the gut; the air-bladder is also asymmetrically placed. The vertebral column, spines, and fins develop asymmetrically according to the balance. Persistent flexures convey the asymmetry to the skull; the intermediate structures, urohyal, arches, jaws, cheek-muscles, showing distorsion and rupture. The basal axis of the skull is flexed to one side, the frontals to the other; the migration of the eye is the final event in a long series of causes and effects.

Many normal Teleosts form a coil and display the same initial disturbances, but their balance is less defective and the skull escapes deformity in various ways; *e.g.*, the body flexures are damped by means of spinous rays, the abdominal cavity is not enclosed by asymmetrical structures, the skull is so strongly depressed that the jaws operate on the dorsal surface, or the jaws operate solely on the head of the vomer.

The metamorphosis being due to defective balance takes place during the pelagic stages; the fish swims and lies on one side because that side becomes the heavier; the side to become the heavier varies according to the balancing organs. After the demersal habit has been attained, changes in fundamental structure are improbable. Hence, essential differences indicate separate origins. The flat-fishes have appeared in phylogeny, that is, the skull became affected by the asymmetry of the body, when the coil of the gut was forming and when the caudal region came to occupy more than half the total length. Nearest the beginning stands the large family of Cynoglossids with intermediate Teleostean characters; at the other end is Psettodes, an isolated species, with advanced characters; between these lie several groups. Confirmation of this view is found in the affinity of each group to separate types of normal Teleosts ranging from the Macrurids to the Percoids.

"Studies in the Cytology of the Statolith Apparatus in Plants, viewed in Relation to their Habit and Biological Requirements." T. L. Prankerd.

Part I. deals with the reaction to external stimuli of some Liverworts and demonstrates that the degree of geotropic irritability corresponds in general with the biological requirements of the plant. It is further shown that the statolith apparatus is also gradational in its expression, *i.e.*, it is usually absent in vegetative thalli where position is of no importance, while it is most strikingly developed in the strongly geotropic gametophores and sporogonia.

Part II. describes the movements executed by fern fronds in response to internal and external stimuli. In a study of some 15 species (representative of the Filicales) geotropic irritability was always present, though both latent and reaction times are greater than the corresponding periods for Angiosperms. A cylinder of statocyte tissue is always developed in the ground tissue of the young rachis, which disappears at about the time of unfolding of the leaflets, when response to gravity also ceases. Detailed work on *Asplenium bulbiferum* shows that a curve expressing the rise and fall in the amount of statocyte tissue present corresponds more closely with the curve of geotropic irritability than with those of heliotropism, epinasty, or growth. It is interesting to note that growth continues some time after the simultaneous loss of the statolith apparatus and the power of gravitational response.

The most important points in this investigation are :—

(1) The demonstration of geotropic irritability in fern fronds, and the physiological evolution implied in the relatively long latent and reaction periods;
(2) The close correlation of this irritability with the development of a statolith apparatus;
(3) The varied types of statocyte occurring in the Filicales, including the "nucleostatolith" of Angiopteris and the curious swing mechanism of Gleichenia.

Ordinary Meeting, April 28, 1921.

Prof. C. S. Sherrington, President, in the Chair.

The following papers were read :—

"Vibrations of a Spinning Disc." By Prof. H. Lamb, F.R.S., and R. V. Southwell.

This investigation was suggested by the occasional failure of the blades of steam turbines, apparently resulting from flexural vibrations of the turbine disc. For practical purposes it will be necessary to calculate the frequencies natural to discs of tapering profile; but the present discussion, which is confined to discs of uniform thickness, illustrates the physical aspects of the problem. The decision to publish a joint paper was reached when it was discovered that both authors had attacked the problem independently, and that their methods and results were closely parallel.

Expressions have been obtained for the gravest natural frequencies of vibration—(1) by exact methods, on the assumption that the disc is so thin, or rotates so fast that the restoring effects of centrifugal force are predominant, and the effects of flexural rigidity negligible; (2) from Kirchhoff's theory for flat circular plates, in cases for which the opposite assumption can be made; and (3) by Rayleigh's approximate method, employing an *assumed* curve of deflection, for cases in which both centrifugal and flexural effects require to be taken into account.

The problem is of theoretical interest, as an example of vibrations in which two distinct systems of restoring forces act simultaneously. A theorem due to the late Lord Rayleigh shows that the results of employing method (3) above must be to *over-estimate* the gravest natural frequency of vibration. As an extension of the same theorem, it is here shown that a corresponding *lower limit* can be obtained by considering each restoring system separately. In the most important case of the problem treated, the upper and lower limits deduced in this way differ by litle more than 1 per cent; the lower limit is the easier to obtain.

"*The Hardness of Solid Solutions.*" By Dr. W. ROSENHAIN, F.R.S.

It is suggested that crystals of a solid solution of metal B in metal A are built up on a single space lattice system similar to that of crystals of pure A, but that certain atoms of A on this space lattice are replaced by atoms of B. As the atoms of B are necessarily somewhat dissimilar from atoms of A, this replacement involves a certain amount of distortion of the space lattice, *i.e.*, atoms of A in the neighbourhood of an atom of B will be pulled or pushed slightly out of their normal position. The amount of such distortion will depend upon the degree of dissimilarity between the two kinds of atoms. If the atoms are sufficiently dissimilar, the distortion will be considerable, and consequently the number of atoms of B which can be introduced into the space lattice of A will be limited. At the same time, the mechanical properties of the crystals will be affected by the slight distortion of the space lattice arrangement, surfaces which were plane gliding surfaces in the crystals of pure A being no longer perfectly plane in the solid solution crystals, and consequently offering an increased resistance to slip within the crystal.

It follows that the greater the distortion introduced into the space lattice by the introduction of an atom of B, the greater will be the hardening effect of the introduction of B into A in the form of solid solution. This leads to the inference, as a rough first approximation, that the hardening effect of one metal upon another in solid solution is inversely proportional to the solubility of that metal in the first. This inference is shown to be in accordance with fact in regard to the alloys of various metals, particularly those of copper with nickel, manganese, zinc, aluminium, and tin respectively; and it is suggested that the law is in general conformity with the known facts concerning the majority of alloys.

"*A Method of Analysing Galvanometer Records.*" By W. HARTREE and Prof. A. V. HILL, F.R.S.

The motion of a galvanometer connected to a thermopile in contact with a body producing (or absorbing) heat is governed by linear differential equations with constant coefficients, and it is possible, from the relation between galvanometer deflection and time, to determine the relation between heat-production and time. It is necessary to construct a "control curve," *i.e.*, the relation between galvanometer deflection and time for an instantaneous liberation of heat in the body on the thermopile. The observed curve may then be reconstructed in terms of the control curve, and employing a numerical method described in the paper, it is possible to make a fair analysis of the course of the production (or absorption) of heat.

"*A New Form of Wehnelt Interrupter.*" By F. H. NEWMAN.

1. The new form of electrolytic interrupter consists of a platinum wire immersed in a saturated solution of ammonium phosphate. The whole is contained in an aluminium vessel, which acts as the cathode.

2. The current density at the anode is only one-quarter of the value in the old form of Wehnelt Interrupter. Consequently there is less heating of the electrolyte, and less disintegration of the platinum wire.

3. The interrupter can be used with alternating currents, which it rectifies.

4. The secondary discharge, obtained from the new type of interrupter, is very disruptive. It has a large peak value.

5. This modified type of interrupter works without self-induction in the circuit, when used with alternating currents.

6. The primary current wave form has been investigated with direct and alternating currents.

"*Some Experiments on Thermal Diffusion.*" By T. L. IBBS.

The experiments were made with the object of investigating experimentally some of the conclusions relating to thermal diffusion, arrived at by Dr. S. Chapman in his Kinetic Theory of Gases, thus extending the experimental work of Chapman and Dootson. The method employed is new, and depends on the use of the katharometer as an instrument for accurate gas analysis. A temperature gradient was applied to a number of mixtures of hydrogen and carbon-dioxide by passing them through a cylindrical glass tube, down the middle of which was a platinum helix. The helix was heated to different temperatures by an electric current. A steady flow of the gas mixture was maintained, and the gases were drawn off from the hot and cold regions of the tube, subsequently passing through a differential katharometer for analysis. The results showed that there was a general tendency for the hydrogen to diffuse towards the hotter region, and the carbon dioxide towards the cooler region, thus confirming the results of Chapman and Dootson. The experiments also show clearly the effect of variation of the temperature gradient on the amount of separation obtained. Curves are drawn showing that the amount of separation is proportional to Log $\frac{T_1}{T_2}$ where T_1 and T_2 are the absolute temperatures of the hot and cold regions. The experiments also show that the greatest amount of separation for a given temperature gradient is obtained in mixtures containing from 50 to 60 per cent by volume of hydrogen. The nature of the results gives strong support to the theory worked out by Chapman. The amount of separation is less than would be expected if gas molecules behaved like rigid elastic spheres.

"*Diffraction of Light incident at nearly the Critical Angle on the Boundary between Two Media.*" By B. N. CHAKRAVARTY.

CORRESPONDENCE.

ESTIMATION OF PHOSPHOROUS IN PHOSPHOR BRONZE.

To the Editor of the Chemical News.

SIR,—The following modification in the estimation of phosphorus in phosphor bronze may be of interest, and many of the details are, I think, new. The following method does away with the necessity of having to fuse the stannic oxide residue which contains the phosphorus present, and is a simple, clean, and above all, accurate method, and can easily be completed in under one hour. The details given below have worked satisfactorily.

To 1 grm. of the alloy 0·5 grm. either iron wire,

or mild steel turnings, is added. The mixed metals are taken into solution with 15 cc. aqua regia (5 cc. HNO_3 : 10 cc. HCl). When solution is effected, boil for a few minutes, cool, and nearly neutralise with AmOH. Sufficient $K_2Mn_2O_8$ is then added, so that a distinct precipitate persists on boiling for two minutes. This is cleared with a few drops HCl. The solution is then cooled and diluted somewhat, and the basic ferric phosphate precipitated with 25 cc. AmOH (0·880 sp. gr.). The precipitate is gradually taken into solution, using strong HNO_3. This should be added from a burette, in order that the neutral point may be obtained. This is easily recognised, being a dark-coloured liquid, free from suspended precipitate. An excess of 3 cc. HNO_3 is then added, the liquid clearing to a bright apple-green solution. This is then brought to the boiling-point, removed from the flame, and the phosphorus present precipitated by the addition of sufficient nitro-molydic reagent.

The precipitate is allowed to stand at room temperature for at least 20 minutes, and is then filtered, washing in the first place with 2 per cent HNO_3, and then washing free from acid with 2 per cent. KNO_3. The phosphorus present is determined by dissolving the precipitate in an excess of std. NaOH, the excess being estimated with std. HNO_3. Using phenolphthalein as an indicator. The solutions are standardised against a steel with a known phosphorus content. The small amount of Phosphorus in the added iron or steel must of course be deducted.—I am, &c.,

GEO. GREENWOOD.

99, The Grove,
Ealing, W.5.

BOOKS RECEIVED.

"Tables of Refracted Indices. Vol. II.—Oils, Fats, and Waxes." Compiled by R. KANTHACK. Edited by J. N. GOLDSMITH. 292 pages. London: Adam Hilger, Ltd. Price 25s. net.

"Clayworkers' Handbook." A Manual for all engaged in the Manufacture of Articles from Clay. By ALFRED B. SEARLE. 381 pages. London: J. J. Griffin & Sons. Price 21s. net.

"Coke Oven and By-Product Works Chemistry." By THOS. BIDDULPH-SMITH. 62 illustrations. 7 folding plates. 180 pages. London: J. J. Griffin & Sons. Price 21s. net.

"Technical Methods of Analysis as Employed in the Laboratories of the Author." By D. LITTLE, Inc. Cam. Mass. Edited by ROGER CASTLE GRIFFIN. First Edition. New York and London: McGraw-Hill Book Co., Inc.

"Animal and Vegetable Fixed Oils, Fats, Butters, and Waxes: Their Preparation and Properties, and the Manufactures therefrom of Candles, Soap, and other Products." By C. R. ALDER WRIGHT. 3rd Edition. Revised and greatly enlarged by AINSWORTH MITCHELL. 3 plates and 185 illustrations. 939 pages. London: J. J. Griffin. Price 56s. net.

"Metallic Alloys: Their Structure and Constitution." By G. H. GULLIVER. Fourth Edition with Appendix. 332 illustrations. xxvii.+439 pages. London: J. J. Griffin. Price 15s. net.

"A Primer on the Storage of Petroleum, Spirit, and Carbide of Calcium: For the Use of Local Inspectors and Motorists." By MAJOR A. COOPER KEY. Second Edition. x.+132 pages, with Appendix. London: J. J. Griffin. Price 5s. net.

NOTES.

ROYAL INSTITUTION.—A General Meeting of the Members of the Royal Institution was held on the 9th inst., Sir James Crichton-Browne, Treasurer and Vice-President in the Chair. Mr. W. E. Watson Baker, Dr. R. Langdon Downe, Mr. R. W. Paul, Mr. A. S. Tabor, and Mrs. S. S. Williams were elected Members. Sir J. J. Thomson was elected Honorary Professor of Natural Philosophy, and Sir Ernest Rutherford Professor of Natural Philosophy.

ROYAL INSTITUTION.—On Tuesday next, May 17, at 3 o'clock, Mr E. Clodd gives the first of two lectures at the Royal Institution, on the "Origin and Development of Occultism." Owing to the illness of Dr. MacColl, the lectures on Thursdays May 19 and 26 will now be delivered by Mr. Ernest Law on "The Architecture and Art of Hampton Court Palace." On Saturday, May 21, Mr. F. Legge begins a course of two lectures on "Gnosticism and the Science of Religions." The Friday Evening Discourse on May 20 will be delivered by Dr. E. H. Starling on the "Law of the Heart," and on May 27 by Mr. A. Mallock on "Elasticity."

WE have received a copy of the "Directory of Paper Makers" for 1921 from Messrs. Marchant, Singer, & Co. The Directory is very complete, and contains all the information likely to be needed by printers, stationers, publishers, and all users of paper. A complete list of watermarks is given, by which it is possible to identify the maker of any water-marked paper, and the list of trade customs gives very useful information to anyone dealing in paper. A list of paper-makers, &c., in the United Kingdom, has been revised and brought up to date. Price 2/9 net, post free in the United Kingdom.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

11646—Alby United Carbide Factories, Ltd.—Manufacture of salts of guanidine. April 22nd.

11553—Buchler, H.—Process of production of boro-di-salicyclic acid. April 21st.

11766—Callimachi, M T.—Manufacture of threads, filaments, etc., of cellulose. April 23rd.

11311—Calorizing Corporation of America.—Mettalis alloys. April 19th.

11771—Courtaulds, Ltd.—Manufacture of carbonbisulphide. April 23rd.

Specifications published this Week.

161591—*Weizmann, C. and Legg, S. A.—Manufacture* of secondary butyl alcohol.

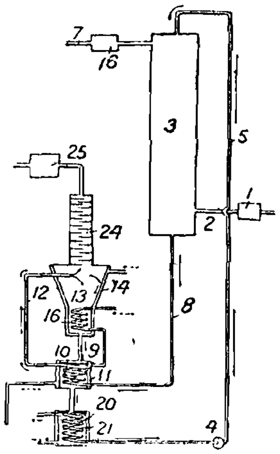
117085—Deutsche Gold-und-Silber Scheide Anstalt vorm. Roessler.—Manufacture of alkali percarbonates.

161656—Mackay, P. A.—Process of obtaining copper sulphate direct from metallic copper.
147583—Still, C.—Method of purifying coal gas by means of ammonia.

Abstracts Published this Week.

Mr. G. C. Claude of 48 Rue Saint Lazare, Paris, has obtained a Patent No. 158593 in this country for improvements to the protecting of the walls of the enclosure in which an exothermic reaction is carried out under high pressure and at a high temperature; for instance, the synthesis of ammonia using "hyperpressures" according to Specification 130086. A layer of molten material interposed between a chamber in which the reaction takes place and a pressure sustaining wall, is, by selection of bad thermic conductivity, neutral with respect to the bodies present, and of low vapour tension; suitable materials are a metallic chloride, caustic soda or potash, a eutectic mixture of the latter, and borax dissolved in boric acid. To prevent transmission of heat by convection, the molten material may be held stationary by the addition of solid material of bad thermic conductivity, such as sand, coke, powdered magnesia, or magnetic oxide of iron, employed in a granular or pulverulent state in such a manner as to form a paste or pulp. Substances such as litharge may be added to the molten material to absorb hydrogen, etc., that may become dissolved therein and which might attack the wall of the enclosure. In the apparatus, the catalyst is contained in the inner tube, surrounded at the lower part by an electrical heating-device, and the reaction gases enter at the connection, pass through the annular or helical space between the tubes, then traverse the catalyst, where they are brought to reaction, and finally escape through the connection. At the point where the gases enter, the temperature is insufficient to lead deterioration of the wall, and it is adequate to continue the molten material to a height at which the temperature ceases to become injurious to the wall. Several layers of liquids may be employed, the more fusible at the top and extending down to a level, and the less fusible from other levels; such viscous liquid may consist of boric acid containing an increasing proportion of borax.

Sulphur Dioxide.—Mr. P. Pascall of 117, Boulevard Haussmann, Paris, has been granted a Patent No. 159337 for a new process of obtaining sulphur dioxide from dilute gas mixtures. For instance gases from the roasting of blende and pyrates by treating the gas mixture under pressure with carbolic oil obtained by distilling coal tar at 175-225°C., and separating the dissolved gas by heat and reduced pressure, after which the gas is liquefied. The dilute gas is compressed by a compressor 1 and delivered by a pipe 2 to a packed tower 3 supplied with oil by a pump 4 through a pipe 5. The issuing gas is expanded in an expander 6 and led by a pipe 7 to apparatus for recovering the last traces of sulphur dioxide. The oil passes from the bottom of the tower 3 by a pipe 8 to a coil 9 in a heat exchanger 10 having a jacket 11 supplied with steam and then it is delivered by a pipe 12 in a tangential jet into an expanding chamber 13 having a steam jacket 14. The oil collecting in the lower part of the expander 13 is heated by a steam coil 16, from which the steam passes through the jacket 11 of the exchanger 10. The oil from the expander 13 passes through the exchanger 10 through a coil 20 in a cooler 21 and thence to the pump 4. The sulphur dioxide separated in the expander 13 passes up a plate tower 24, which separates oil vapour, to a suction pump 25 after which it is liquefied.



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MEETINGS FOR THE WEEK.

Tuesday, May 17.

Royal Institution, 3. "Occultism—Its Origin and Development" by Edward Clodd.

Wednesday, May 18.

Royal Microscopial Society, 5.

Thursday, May 19.

Royal Institution, 3. "The Architecture and Art of Hampton Court Palace" by Ernest Law.
Institution of Mining and Metallurgy, 5.30
Chemical Society, 8.

Friday, May 20.

Royal Institution, 9. "The Law of the Heart" by Dr. E. H. Starling.

Saturday, May 21.

Royal Institution, 3. "Gnosticism and the Science of Religions" by Francis Legge.

NOTICES.

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Further particulars may be obtained from the undersigned, by whom 100 copies of applications and testimonials, (except for the last-named post for which three copies, which need not be printed, will suffice), must be received on or before May 28th, 1921.

D. J. A. BROWN,
Registrar.

University College, Cardiff.
April 22nd, 1921.

PATENTS, TRADE MARKS. Handbook and advice free—B. T. KING, British and U. S. Regd. Patent Attorney, 146a, Queen Victoria St., London. 35 years reference

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THE CHEMICAL NEWS.
VOL. CXXII., No. 3188.

FRACTIONAL DISTILLATION WITH CONTACT RING STILL-HEADS.*

By Dr. R. LESSING.

THE author draws attention to the advantages of packing absorption towers and distilling columns with contact rings of the type described in his Brit. Pat. No. 139,880. These rings consist of cylinders of approximately equal height and diameter, having a gap in the circumference and a more or less diametrical partition connected on one side with the cylinder, but out of touch on the opposite side. They are disposed indiscriminately in the tower or column at the angles which they find when dropped promiscuously into a vessel. The provision of the central partition and openings has been found to increase the efficiency of this packing over Raschig rings by increasing the contact surface available in a given tower space and the drainage capacity.

The standard rings of 1in. diameter by 1in. height are used in a great variety of plants of the chemical and gas industries, amongst which may be cited ammonia scrubbers, absorbers, washers, tar extractors, carbolate decomposers, carbonating and decarbonating towers, debenzolising stills, distilling columns and still-heads for many substances such as tar and petroleum products, alcohols and essential oils, condensers, coolers, heat exchangers, and are applicable wherever large interfacial surface for liquid and gas or vapour, combined with a minimum of back pressure is essential.

Smaller sizes of Lessing contact rings down to ¼in. diameter are now available, and are particularly useful for the construction of laboratory still-heads on the lines on which the larger rings are applied in manufacturing operations. They have a surface of 8250 sq. cm. per litre (251 sq. feet. per cubic foot), and only occupy 13 per cent total space, leaving 87 per cent of free space for vapour and condensate. The resistance of such still-heads is almost negligible and they can therefore be made of considerable height.

They are simple in construction, and the rings can be transferred from one column to another, or be used in absorption towers or reaction vessels, and are therefore of general applicability. They have a remarkable fractionating efficiency, and are in this respect superior to other dephlegmators. This efficiency is due to the large surface per unit of volume, the turbulence created by frequent deflection of currents of vapour and condensate, and the consequent absence of channeling.

In order to obtain the maximum efficiency, the author recommmends lagging or even heating of the still-head to avoid undue condensation, and to provide a reflux condenser, or to use a definite length of the still-head itself as reflux condenser. Thus, return flow and irrigation of the whole length is obtained. A ring packed still-head may then be regarded as a scrubber in which the ascending vapours are scrubbed with the descending condensate.

Still-heads can be constructed from plain glass tubes or metal pipes by merely dropping the rings into them.

The paper contains a number of graphs proving the efficiency of fractionisation obtainable. From a mixture of equal portions of benzene and toluene 47 per cent of benzene distilled within less than 1°, and a like portion of pure toluene was yielded, leaving only about 5 per cent of the total volume in the mixed middle fraction.

From a crude coke oven benzol, almost all the benzene and toluene could be distilled off each within 0·2° C., although the sample contained 30 per cent of naphthalene and wash oil. The effect of still-head dimensions, heat insulation and reflux condensing is shown in one set of curves. Another chart deals with the distillation of fusel oil, and a remarkably sharp separation of the various higher alcohols from each other and from water is shown in a further graph. The fractionating effect is so sharp that chemically anhydrous alcohol may be in the lower part of the still-head, while there is sufficient water in the upper portion to separate as a distinct layer from the distillate.

* Read at the Meeting of the London Section of the Society of Chemical Industry, Monday, May 2, 1921.

METHODS FOR THE COMPLETE RECOVERY OF NITRE CAKE.*

By W. H. H. NORRIS, B.A., B.Sc.

PREVIOUS to 1915 the utilisation of nitre cake in this country was on a comparatively small scale. During the war over 80 per cent of the considerably increased production was employed, but largely by methods which completely wasted the sodium sulphate contents. With ample supplies of sulphuric acid, only those methods of recovery will stand which are economically sound, and the production of by-product salt cake in a pure and marketable form will assist in this direction.

Processes of war expediency may be passed over. The oldest method for complete recovery was by the salt cake furnace, and this well-known operation calls for little comment. Expenditure on hard coke at present prices is a considerable charge, and where hydrochloric acid is the valuable product, nitre cake has little chance of competing with sulphuric acid because of the reduced yield per furnace, and the impurity of acid produced when nitre cake is employed.

Many other methods have been suggested, but the writer does not know that any of these have been carried out on a manufacturing scale with the exception of the following.

Nitre cake may be used for ammonia absorption producing sulphates of ammonia with the additional formation of sodium sulphate suitable for glass makers.

A process was described which has been worked out in conjunction with H. S. Denney and C. W. Bailey, and 220 tons of nitre cake used to produce 157 tons of salt cake and 87 tons of ammonium sulphate by it. The plant was run in conjunction with a Mond Gas Ammonia Recovery Plant, and proved successful in operation, process figures and costs for which were given.

The method is of wide application and may be used either with ammonia absorption towers and

* A paper given before the Manchester Section of the Society of Chemical Industry, May 6th, 1921.

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dasher washers or in the ordinary saturator as employed on coke oven and gas works liquor recovery plants. The operation works up all its own waste liquors, and requires the minimum of handling and evaporation.

Briefly, the nitre cake is digested with hot process liquor, and the whole of its contents of salt cake are precipitated in a pure form, while all the acid is taken into solution. The mixture is filtered, and washed in centrifugals, and the acid liquor resulting used for ammonia absorption, in the saturator or other absorption plant. The neutralised liquor is evaporated in the usual way, for the deposition of sulphate of ammonia containing over 24 per cent free ammonia, but concentration is checked when a definite density is reached, and the process liquor run back to the digester to extract the acidity from a fresh charge of nitre cake.

THE SEPARATION AND DETECTION OF ARSENATE AND ARSENITE.

By, GEO. W. SEARS.

Of the methods now available for the detection of arsenate and arsenite those based on the formation of arsine (*Chem. Ztg.*, xxxiii., 1209; *Z. anal. Chem.*, 1902, xli., 362) and those taking advantage of the oxidising power of arsenates (*Am. J. Sci.*, [3] 1894, xlviii., 216) or the reducing power of arsenites (*ibid.*, [4] 1896, i., 35) are perhaps the most common. The limited applicability of these methods to a general separation and detection of the more common acid radicals led the author to make a study of the relative solubility of their silver salts in various concentrations of sodium hydroxide. When silver arsenite, to which potassium hydroxide has been added, is allowed to stand in the sunlight or is heated to 50° on the water-bath, the arsenic slowly dissolves with the formation of potassium arsenate (*Ber.*, 1894, xxvii., 1019). No information, however, was available regarding the effect of alkaline solutions other than ammonium hydroxide, on silver arsenate. Both salts are readily soluble in ammonium hydroxide ("Dictionary of Chemical Solubilities, Comey, pp. 37-42). An examination of the two salts with respect to their relative solubility in excess of sodium hydroxide leads to a study of the following equilibria.

$$2Ag_3AsO_4 + 2NaOH + H_2O \rightleftarrows 2NaH_2AsO_4 + 3Ag_2O \quad (1)$$

$$2Ag_3AsO_3 + 2NaOH \rightleftarrows 2NaAsO_2 + 3Ag_2O + H_2O \quad (2)$$

$$2Ag_3AsO_3 + 6NaOH \rightleftarrows 4Ag + Ag_2O + 2Na_3AsO_4 + 3H_2O \quad (3)$$

Experimental.

Preparation of Silver Arsenate and Silver Arsenite.—Weighed amounts of the C. P. sodium salts were dissolved in enough water to make a concentration of 10 mg. of the acid radical per cc. of solution. Definite volumes of these solutions were diluted, acidified with nitric acid and an excess of silver nitrate was added. To the resulting mixture sodium hydroxide was added drop by drop with constant stirring until the black precipitate of silver oxide just failed to redissolve. The appearance of the black silver oxide is very definite and easy to detect, and hence makes a very satisfactory indicator. Under these conditions the solution has an acidity of about 10^{-5} to 10^{-7}. It reacts acid toward phenolphthalein and basic toward methyl orange. With congo red an orange to violet colour is obtained. Both silver arsenate and silver arsenite are completely precipitated, and can be filtered with ease. (The filtrate does not give a precipitate with H_2S.) The salts obtained in this way and containing a definite weight of the acid radical were removed from the filter by means of a fine stream of water. This resulted in a rather finely divided suspension to which the solvent was added.

Solubility of Silver Arsenite.—Approximately 6 *N* sodium hydroxide solution was added to the precipitate of silver arsenite suspended in 10 to 20 cc. of water as indicated above, and after a thorough mixing, the mixture was filtered and both precipitate and filtrate tested for arsenic as follows. The precipitate was leached with 6 *N* hydrochloric acid to dissolve the arsenic and remove the silver. The clear solution was then saturated cold with hydrogen sulphide. The filtrate was strongly acidified with hydrochloric acid and saturated with hydrogen sulphide. Table I. shows the behaviour of silver arsenite toward various concentrations of sodium hydroxide. The residue invariably gave a positive test, and the filtrate a negative test, except in the last experiment, when the filtrate gave a positive test.

TABLE I.

Mg. AsO_3'''.	Cc. of Approx. 6 *N* NaOH	Total volume cc.	Approx. normal strength.
0·5	0·2	10	0·12
1	0·2	10	0·12
10	0·2	10	0·12
100	0·2	10	0·12
0·5	0·5	10	0·3
10	0·5	10	0·3
100	0·5	10	0·3
0·5	1	25	0·24
100	1	25	0·24
1	2	25	0·48
1	5	25	1·2
50	5	20	1·5
50	5	15	2

The results obtained show that cold sodium hydroxide up to about 1·5 *N* has no solution effect on silver arsenite, though higher concentrations seem to have a slight solvent action. In Reichard's work (Reichard, *Ber.*, 1894, xxvii., 1019) on the action of potassium hydroxide on silver arsenite no statement is made regarding the concentration of potassium hydroxide solution used, hence it seemed advisable to repeat a part of his work, using small concentrations of sodium hydroxide solution. The results obtained from a number of experiments showed that at the temperature of the water-bath silver arsenite is slowly dissolved in 0·5 *N* sodium hydroxide solution. The reaction proceeds almost entirely according to Equation 3 above, as shown by the fact that only a trace of arsenic could be detected by precipitation with hydrogen sulphide from a cold hydrochloric acid solution, while a considerable amount of metallic silver was left in the

residue. On the other hand, when the mixture was kept cold no reaction was detected in concentrations of sodium hydroxide below 1·5 *N* and in higher concentrations (4-6 *N*) reaction according to Equation 2, seemed to predominate, although the presence of small amounts of metallic silver in the residue showed that some arsenic was dissolved according to Equation 3. Even in 6 *N* sodium hydroxide solution only a small fraction of the silver arsenite present was dissolved.

Solubility of Silver Arsenate.—In the investigation of the solubility of silver arsenate experiments were carried out in the same manner as those with silver arsenite except that the residue after leaching with hydrochloric acid was heated to boiling before saturating with hydrogen sulphide. The filtrate was acidified with acetic acid and the arsenate precipitated with uranyl acetate The resulting uranyl arsenate was then dissolved in hydrochloric acid and arsenic precipitated with hydrogen sulphide as before. Preliminary experiments showed that some silver arsenate dissolved even in very small concentrations (0·05 to 0·1 *N*) of sodium hydroxide but seemed to indicate incomplete solution when as much as 5 mg. of the arsenate radical was present. With 0·5 to 1 mg. of arsenate, solution was complete as shown by a negative test on the residue and a positive test in the filtrate. When 50 to 100 mg. was used a considerable proportion seemed to dissolve, but in all cases the residue gave a positive test. Increasing the concentration of the sodium hydroxide made very little change in these results, while increased dilution of the arsenate seemed to give a greater solution effect. (Later work showed that these results were due in large measure at least to insufficient washing of the silver oxide residue).

The result of preliminary experiments indicated that an equilibrium was established in which perhaps 75 to 80 per cent of the arsenate was dissolved. It seemed worth while, therefore, to make a more careful study of the equilibrium

$$2Ag_3AsO_4+2NaOH+H_2O \rightleftarrows 2NaH_2AsO_4+3Ag_2O$$

in order to find out if possible the conditions under which it might be shifted to the right and complete solution of the arsenate be obtained. To this end several experiments were carried out as described above.

TABLE II.

AsO_4'''. Mg.	Cc. of approx. 6 *N* NaOH	Total volume cc.	Approx. normal strength	Residue
0·5	0·3	10	0·18	Neg.
1	0·3	10	0·18	Neg.
1	0·25	25	0·06	Neg.
10	0·5	25	0·12	Neg.
25	0·5	25	0·12	Pos.
50	1	25	0·24	Neg.
100	1	25	0·24	Neg.
150	1	25	0·24	Pos.
150	2	25	0·48	Neg.
200	2	25	0·48	Neg.
250	2	25	0·48	Pos.
400	3	25	0·72	Neg.
450	3	25	0·72	Neg.
1	0·13	25	0·03	Pos.

Various concentrations of sodium hydroxide were added to the precipitate of silver arsenate, suspended in water, and the mixture was well stirred before filtering. The silver oxide residue was then washed till the wash water gave no further test for alkali with litmus paper.

Table II. shows the behaviour of silver arsenate toward various concentrations of sodium hydroxide. The filtrate gave a positive test in every experiment except the last, which was negative.

It may be seen from the above results that the solvent action of sodium hydroxide on silver arsenate increases very rapidly with increasing concentration, and is appreciable at concentrations as low as 0·06 *N*. No action is apparent, however, in 0·03 *N* sodium hydroxide solution.

Discussion.

From the foregoing results it is evident that a quantitative separation of arsenate and arsenite may be obtained by the action of sodium hydroxide solution (0·5-1·5 *N*) on their silver salts, the arsenate passing into solution. Higher concentrations of sodium hydroxide react slowly with silver arsenite with the formation of a mixture of soluble trivalent and pentavalent arsenic, probably according to Equations 2 and 3 above. Even very high concentrations, however, seem to have but slight solvent action in the cold.

It would seem, therefore, that some influence other than is apparent in the equilibrium represented by Equation 1 must come into action to affect the solution of silver arsenate since similar forces seem to act in the opposite direction in Equation 2. A compound of the formula $(As_2O_5)_2.3NaOH$ has been described by Filhol and Senderens as being formed by the action of excess sodium hydroxide on arsenic acid (Filhol and Senderens, *Compt. Rend.*, 1881, xciii., 388). They obtained it crystalline form only after evaporation to a syrupy consistency. No evidence of a similar action with arsenious acid was found. This difference in tendency toward complex formation with sodium hydroxide may, therefore, account for the difference in solubility of the silver salts. Without the formation of a complex ion the equilibrium represented in Equation 1 should shift toward the less soluble silver salt as is apparently the case in Equation 2.

Procedure.

(1) *Precipitation.*—To a nitric acid solution of the acids containing an excess of silver nitrate add sodium hydroxide drop by drop from a pipet until on shaking the dark silver oxide precipitate just fails to redissolve. Filter, wash the precipitate and transfer it to a graduate cylinder by means of 15 to 20 cc. of water from a wash bottle. Add 2 to 3 cc. of approximately 6*N* sodium hydroxide solution and fill up to the 25 cc. mark with water. The amount of sodium hydroxide that should be added depends on the quantity of arsenate present. More than 450 mg. of arsenate is completely dissolved in 25 cc. of solution containing 3 cc. of 6 *N* sodium hydroxide solution while as much as 5 cc. of the alkali in 25 cc. of solution produces no solvent action on the arsenite. Transfer the contents of the cylinder to a beaker and mix thoroughly. Filter, and wash the residue free from alkali. Test the residue for arsenite and the filtrate for arsenate.

(2) *Detection of Arsenite.*—Dissolve the residue of silver arsenite (1) by pouring a 5-cc. portion of 6 *N* hydrochloric acid repeatedly through the filter and add hydrogen sulphide to the clear solution obtained. If a dark precipitate is obtained show-

ing the presence of heavy metal sulphides insoluble in hydrochloric acid, it may be tested for arsenic according to the usual methods.

(3) *Detection of Arsenate.*—The filtrate from (1) contains the arsenate which may be separated by acidifying with acetic acid and adding uranyl acetate in slight excess. The arsenate is precipitated as uranyl hydrogen arsenate, UO_2HAsO_4. If the precipitate should be colloidal or finely divided it may be collected and readily filtered by shaking with a pinch of asbestos fibre. The uranyl arsenate is readily soluble in hydrochloric acid from which it may be precipitated as sulphide by means of hydrogen sulphide.

The method has been successfully used by the author's classes in qualitative analysis as a means of detecting arsenate and arsenite either alone or in the presence of each other.

Summary.

A procedure is described for the separation and detection of arsenate and arsenite.

The separation is based on the relative solubility of their silver salts in sodium hydroxide.

Data in support of the procedure are furnished. The method is capable of detecting 1 mg. of either ion in the presence of 450 mg. of the other.—*Journal of the American Chemical Society*, March, 1921.

THE PRESENT POSITION OF CHEMISTRY AND CHEMISTS.*

By Prof. N. T. M. WILSMORE.

(Concluded from p. 223).

In view of their peculiar notions of honour and humanity, it is not surprising that early in the war the Germans yielded to the temptation to make use of the great superiority in chemical resources which they then possessed, in an attempt to overwhelm the resistance of the Allies by launching surprise attacks with poison gas. As already mentioned, the end, from their point of view, very nearly justified the means; but it may be doubted whether towards the close of the war, when the Allies' reply in kind was becoming effective, they were quite so pleased with their innovation.

Owing to the ease with which free chlorine can be absorbed and rendered harmless, it was soon superseded for offensive purposes by various poisonous compounds, most of which, however, contained chlorine as a constituent. Of these compounds, perhaps the most important were phosgene and $\beta\beta$dichlordiethyl sulphide, the so-called "mustard gas," the latter being first used by the Germans in July, 1917. Owing, apparently, to faulty organisation, on the part of the Department originally concerned, the production of poisons in Britain failed for some considerable time to meet requirements; but in April of 1918, the whole of the manufacture and supply was transferred to the Explosives Department. As this manufacture was given the highest priority, the whole of the comprehensive scientific and technical resources of the latter Department were at once applied to it, and a vigorous programme was taken up. In the meantime, a simplified method for making mustard gas by the action of ethylene on sulphur monochloride had been discovered in the Chemical Department of the University of Cambridge; and, although the working out of this method on a technical scale was still far from complete, its advantages over the cumbrous method used by the Germans were so obvious that it was decided to adopt it. An existing factory, which had been shut down, was rapidly reconstructed for the new manufacture, first on an experimental, and later on a large scale; and, owing to the strenuous and self-sacrificing labours of the technical staff, the process made such headway that by the following September 50 tons of this fearsome compound had been delivered to the shell-filling factories. This amount, however, was only a preliminary sample of what the factory was planned to make, but before it could get into its stride the war had ended.

It is of interest to note that the first consignment of shells filled with British mustard gas was delivered to the Australian Army Corps, and was used by it in the operation of finally piercing the Hindenburg Line at Bellicourt. To quote General Monash, "Australian Victories in France," p. 255: "The first phase of the bombardment was of a novel character. For over two years the enemy had been using a shell containing an irritant and poisonous gas known as "mustard gas." . . . For a long time we had been promised that the British Artillery Service would shortly be supplied with a gas shell of similar character. It was moreover anticipated that the German gas mask would prove no adequate protection against this kind of gas. At last the new shell was forthcoming, and the first shipment from England, amounting to some 50,000 rounds, was placed at the disposal of the Australian Corps. My artillery action, therefore, opened with a concentrated gas bombardment of 12 hours, attacking probable living quarters, occupied defences, and all known or suspected approaches to them."

Later information from prisoners and other sources disclosed that the effect of this bombardment on the Germans had been most demoralising. For months previously the German troops had been assured that mustard gas would win the war for them; that no troops could stand against it; and that the British could not hope to make it. The subsequent disillusionment was, therefore, one more convincing proof that the game was up.

As the multifarious activities of the Explosives Department and of the other Departments under the Ministry of Munitions developed, the amount of research work which became necessary was very great. The Explosives Department itself had a laboratory specially set apart for research, and researches were also constantly in progress on the plant and in the laboratories in all the factories controlled by it. These resources, however, even when supplemented by those of the Research Department at Woolwich, proved inadequate to supply the mass of information which was constantly required; so a special Section of the Explosives Department was formed and entrusted with the duty of arranging for and co-ordinating research work in the laboratories of the Universities and technical schools throughout the country. Although greatly hampered by want of assistance, the teaching staffs of these various institutions responded enthusiastically to the call; so that innumerable problems involving chemistry, physics, engineering, and in fact every branch of science, were rapidly solved as they arose, and thus the

*Presidential Address, delivered before Section B (Chemistry), of the Australasian Association for the advancement of Science at the Meeting held in Melbourne.

smooth working of this gigantic war machine was made possible.

In this way the Department of Explosives Supply accumulated an immense and varied amount of most valuable information; and it was Mr. Quinan's earnest wish that, when the war was won, this information should be made available for the benefit of the industries, and especially the chemical industries of Britain and her Allies. Fortunately this is now being done, the necessary editing having been placed in the able hands of Mr. William Macnab, who was himself one of Mr. Quinan's foremost colleagues on the Headquarters Staff of the Department. The first instalment of the Reports, entitled "Preliminary Studies for H.M. Factory Gretna, and Study for an Installation of Phosgene Manufacture," has already been published. The latter portion of this Report contains a detailed discussion of the lay out of a plant to produce about 250 tons of phosgene per week, and affords an excellent example of Mr. Quinan's creative methods for attacking a new problem. The plant in question was in course of erection at the close of the war, and would have proved a valuable asset, had there been any further campaign. These Reports will be of the greatest value both to designers of chemical plant and to students of chemistry and chemical engineering, and should be added to the library of every university and technical school.

It should be mentioned that the Department of Explosives Supply also derived most useful help from the disclosure by private firms of information on various matters, which before the war had been jealously guarded as "trade secrets." This pooling of information already in existence in itself enabled great advances to be made. British chemical industry has been heavily handicapped in the past by the exclusiveness and secrecy of individual firms, whilst, on the other hand, its rivals in Germany and in the United States have derived great benefit from the exchange of knowledge amongst themselves. The commanding position of the British engineering trades has no doubt been largely due to the fact that in their case this policy of secrecy has for the most part been impossible, so that a discovery or invention made by one firm is at once of advantage to all.

My reason for dwelling so long on the work of British chemists in the war is two-fold. In the first place, the record of that work affords what should be convincing proof that chemistry and chemists are indispensable factors in the constructive work of peace. In the second place, the term "British" in this connexion includes "Australian," for Australian chemists formed no inconsiderable proportion of the technical staff of the Department of Explosives Supply. One cause of this was the supineness of the British Government early in the war, in allowing the chemists of the United Kingdom, who were all too few in any case for the chemical work ahead, freely to enlist in the fighting forces; so that, when the great factories were approaching completion, an urgent call for chemists had to be sent out to all parts of the Empire.

The future status of chemistry and chemists is intimately bound up with the quantity and quality of the training which chemists undergo. Hitherto many chemists have been using their generic name in an inexcusably loose fashion to include, not only thoroughly trained and competent all-round men, but also mere testers or works foremen, who have served a sort of apprenticeship in a chemical laboratory or works, but who, although they may sometimes be highly skilled in some one restricted branch of chemistry, have only the merest smattering of chemistry as a whole. The advancement of chemistry as a profession is seriously endangered by such a practice as this. We must begin by taking ourselves and our profession seriously, if we wish to be taken seriously by the members of other professions, and admitted by them to equal professional status.

On the whole, the general university curriculum for a science degree in chemistry has come out well from the test of the past few years. A broad and thorough training in pure inorganic, organic, and physical chemistry, together with a good working knowledge of mathematics, physics, and modern languages (including English), has shown itself to be the only satisfactory basis for any chemical career worth having. For teaching and for research in pure chemistry, a training on these lines would appear to suffice. But the number of chemists who are disposed to, or are fitted for, these fields of work will always be limited, and the majority will have to seek their living as analysts or consultants or in the industrial field. For industrial chemists in general, some knowledge of engineering is a great advantage, as even when they do not themselves undertake the design and erection of plant, it enables them to discuss with engineers problems which are common to both in language which the engineer understands. For those who intend to specialise as engineer-chemists or chemical engineers, a training in engineering as well as in chemistry is, of course, essential. In this connection a perusal of the Report of the Discussion on "The Training and Work of the Chemical Engineer," held by the Faraday Society in London nearly four years ago, may be recommended.

The concensus of competent opinion in Britain at the present time is that a chemist, to be worthy of the name, should have had a systematic day training in all important branches of chemistry, extending over at least four years, and leading to a B.Sc. degree with first or second class honours in chemistry at the end of it. This qualification is now accepted as a minimum for admission to the Associateship of the Institute of Chemistry of Great Britain and Ireland. That Institute will, however, admit candidates for the Associateship who have obtained their training in evening classes, provided that this training has extended over at least five years, and that during that time they have been engaged in chemical work in the day time. In the United States a high standard of training for chemists is also required. A Committee of the American Chemical Society recently reported that the training of a professional chemist should extend over not less than five years, the final year being devoted chiefly to training in research. This last is a very important provision, because success in industrial as in academic chemistry depends on ability to attack new problems and to strike out into new lines of thought. There has been too great a tendency on the part of British-trained chemists in the past to go straight into works or into an analytical laboratory on the completion of their routine course, without wait-

ing to acquire any experience in research work at all. It is perhaps not unconnected with the high standard of training required that chemists in America are now commanding higher salaries than engineers of equivalent status.

It is to be hoped that the Australian Institute of Science and Industry, for which, as for so many advances in Australian science we are indebted largely to the initiative and energy of Prof. Orme Masson, may fulfil the purpose for which it was originally planned. For in that case it would open up wide fields of employment for Australian scientists in general and chemists in particular. Just now, however, there seems to be grave danger of the usefulness of the Institute being seriously hampered by a mixture of political interference and political inertia. In other words, it will probably ere long be dragged down into the dull and spiritless routine of a Sub-Department of the Commonwealth Public Service. The free spirit of scientific enquiry does not thrive in the atmosphere which surrounds the vote-catching machine. In any case, at the present intellectual level of our Australian Democracy, science could hope to catch but few votes. The prospects of the Institute maintaining the high level of achievement which it has hitherto shown, and becoming of permanent service to the country, like the British National Physical Laboratory, or the United States Bureau of Standards, are therefore growing dim. Already the country is the poorer through failure of the powers that be to take seriously and to give effect to recommendations which the Institute, or rather the Advisory Council has made. To cite one example—the question of supplies of liquid fuel in Australia is becoming desperate. Yet, instead of following up the valuable suggestion of the Advisory Council to utilise for the manufacture of industrial alcohol the immense amount of fermentable material now going to waste, it is proposed to spend untold sums in the less constructive but more showy and speculative enterprise of scratching the country for oil, which, in the opinion of many geologists, is probably not there. Unless the Institute of Science and Industry is given an autonomous position under scientific and technical control and free from the strangle-hold of official red tape, any money spent on it might as well be thrown away.

I must claim your indulgence for having dealt so long on matters connected with applied chemistry to the exclusion of pure chemistry. My only excuse is that the achievements of applied chemistry, especially those connected with the war, seemed likely to appeal more strongly to a general audience. In reality, however, as every chemist knows, the achievements of applied chemistry are merely the outcome of the more fundamental discoveries of pure chemistry, the ultimate source of all real advance in applied, as in pure chemistry, being the pursuit of chemical discovery for its own sake. That a realisation of this is growing in some technical circles is evident from the valuable papers on pure science, emanating from time to time from research laboratories belonging to manufacturing firms, of which the General Electric Co. of America is a notable example.

A first essential for real advance in technical chemistry in Australia is therefore adequate endowment and equipment for research as well as for teaching of our various university chemical departments. Much in this direction has already been done, and the splendid record of the chemical schools of the older Australian universities and of the men whom they have trained shows that it has been money well spent. But much more must be done if we are to hold our own in the strenuous times ahead of us and contribute our proper share to the progress of our science. Hence it is sincerely to be hoped that the appeals for increased help to meet their ever-growing needs, which are being made by the various Australian Universities, will meet with a sufficiently generous response to justify Australia's claim to be a progressive and intelligent nation.

The progress in pure chemistry during the past few years has probably been as epoch-making as that of any previous period. We seem to be getting appreciably nearer to the heart of things. As has so often been the case, the most striking results have followed from the co-operation of chemistry with other branches of science, and above all with physics. To attempt to give even the most cursory summary of recent discoveries in the time now available would be fruitless. Art is long, and your patience must be growing short. Fortunately as regards one of the most important and fundamental problems of chemistry or physics, namely, the structure of the atom, the present position is to be laid before you by abler exponents.

I am afraid that the foregoing remarks have been somewhat discursive and fragmentary. Many of them have been made before by others, some of them many times. However, I have not attempted to say anything original, and certainly I have not succeeded. But if I have managed to supply my fellow chemists with a few reasons in a handy form for the faith which is in them, I shall be content.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, May 5, 1921.

PROF. C. S. SHERRINGTON, President, in the Chair.

THE CROONIAN LECTURE was delivered by DR. HENRY HEAD, F.R.S., on *"Release of Function in the Nervous System."* The following is a summary:—

Hughlings Jackson's law that destuctive lesions do not cause positive effects, but induce a negative condition, which permits positive symptoms to appear. Control of higher over lower centres. Structural lesions may remove this dominance, and so reveal the activity of subordinate centres; this is "disintegration" of function. Should the stimulus become abnormally intense, or central resistance be weakened, forms of reaction may break through which are normally suppressed; this is "escape from control."

§ 1. *Disintegration.*—Sherrington's experimental proof of Jackson's law. Decerebrate rigidity. Condition of the lower end of the spinal chord in man after division or abolition of conduction. The "Mass-Reflex." Wide receptive field, massive

reaction, facilitation of bladder and rectum. Thalamic over-reaction to potentially affective stimuli, both painful and pleasurable.

Vivid response after division of peripheral nerves; not "hyperæsthesia," for threshold may be high. Due to uncontrolled reaction of the spot system. Characteristics of protopathic sensibility; extent of stimulus of greater importance than its intensity; a warning mechanism; sensation diffuse and referred to remote parts. Excessive reaction both to pleasure and pain. Confined to parts which respond to pricking, heat, and cold, but not to lighter contracts.

§ 2. *Escape from Control.*—Integration of afferent impulses and of reflex activities in the central nervous system. Many afferent impulses never reach consciousness, but carry out co-ordination, &c., on reflex levels. Simplest sensory act, the product of prolonged integration and of a struggle for physiological dominance. Many impulses capable of arousing sensation are not permitted to reach the highest centres.

Visceral insensibility is a phenomenon of synaptic resistance rather than of absence of afferent impulses. Double supply of viscera (1) deep sensibility, responding to movement and pressure, but not to pricking, heat and cold; pain produced by excessive pressure or abnormal movement. (2) Protopathic, responding to pain, and in some organs, such as bladder and œsophagus, to heat and cold.

Referred pain. Spreads widely owing to intensity of stimulus, its duration, or to lowered central resistance (menstruation, fever, anæmia, psychical states). Similar escape from control of impulses from other sense organs which have been dominated in the acquisition of some new aptitude. Rotatory stimuli: adaptation and breakdown of control in central nervous system during aviation.

ROYAL SOCIETY CONVERSAZIONE.

THE Conversazione was held at Burlington House, May 11, 1921, with the usual success, and a large number of exhibits were shown. A few that are likely to be of interest to our readers are noted below. An interesting lecture was given by the Rev. JOHN ROSCOE on the "*Primitive Races in Uganda.*"

Gravity Torsion Balance.

This instrument was designed by Baron R. Eötvös, Professor of Physics at the University of Budapest, in order to determine the variation of gravity over comparatively short distances, and to make experimental investigations on the form of the earth. The instrument has also been used in Hungary for the location of mineral deposits when the density of the mineral differed considerably from that of the surrounding strata.

Prof. ONNES, For.Mem.R.S., Sir R. A. HADFIELD, F.R.S., and Dr. H. R. WOLTJER. Apparatus and Specimens used in Research on the Influence of Low Temperatures on the Magnetic Properties of Alloys of Iron with Nickel and Manganese.

A series of iron-manganese and iron-nickel alloys were exposed to the temperatures of liquid air, liquid hydrogen, and liquid helium respectively, and the specific magnetism tested after return to atmospheric temperatures. Tests were also made during immersion in liquid hydrogen (—253° C.). The alloys with the higher percentages of manganese cannot be made magnetic even by immersion in liquid helium (—269° C.). The existence of one magnetic and one non-magnetic manganese-iron compound is shown to be probable.

THE HON. SIR CHARLES PARSONS, F.R.S., and Mr. STANLEY S. COOK. An attempt to reach high instantaneous pressure by the collapse of a hollow sphere of lead under external pressure suddenly applied by explosive.

The sphere is made up of two hemispheres placed together with tissue paper between and soldered around the periphery of the joint. In the cavity is placed the substance to be compressed. If its final diameter in nuclear form is 1÷200th that of the initial hollow and the pressure of the explosive 20 tons per square inch, the nuclear pressure produced is one million tons. The explosive is fired in six places simultaneously.

Mr. J. E. BARNARD. The Microscopic Appearance of Animal Tissues in Ultra-Violet Light.

Certain animal tissues show marked differentiation of structure when illuminated by means of ultra-violet light. The image obtained is a fluorescent one and the resulting colours or tints depend on differences of chemical constitution. Such images are often dissimilar from those resulting from staining reactions. The light filter used is glass transparent to ultra-violet radiations, approximately 300 to 400 $\mu\mu$ wave length, made by Messrs. Chance Brothers. This is combined with a quartz cell filled with a 20 per cent solution copper sulphate. The optical illuminating system is of quartz and the substage quartz condenser is of the "dark-ground" type. Apart from the biological interest of the method the image so formed is of considerable value for testing the optical qualities of microscopic objectives as the object so illuminated is a perfectly self-luminous one.

Radiological Branch, Research Department, Royal Arsenal, Woolwich. Pinhole photographs of the Coolidge Radiator Tube and Photographs Illustrating Protection in the X-ray Examination of Materials.

(1) Pinhole photographs illustrating the change in shape of the focal spot with current change. (2) Photographs illustrating the various parts of the target of the above tube which emit X-rays under varying conditions. (3) Photographs illustrating X-ray protection when radiographing large metal objects. (4) Photographs illustrating portable set designed and made in the Research Department, Woolwich, with complete protection for visual examination of materials.

Dr. E. E. FOURNIER D'ALBE. Latest Form of the Optophone.

The optophone is an instrument which enables totally blind people to read ordinary printed books and newspapers. It is based upon the reflection of beams of rapidly intermittent light from the type on to a selenium preparation, which produces sounds in a telephone varying according to the shapes of the letters. The instrument shown is kindly lent by the National Institute for the Blind, London, where it is in daily use.

PHYSICAL SOCIETY.

March 22, 1921.

Prof. W. Eccles, F.R.S., Vice-President, in the Chair.

The following papers were read :—

"The Effect of Viscosity on Orifice Flows." By Mr. W. N. Bond.

Determinations were made of the coefficient of discharge through an orifice 0·1469 cm. in diameter of solutions of glycerin and water, varying in kinematic viscosity from 0·01 to 7. The results are plotted in a manner which combines both purely turbulent flows in one graph. It is shown that the effect of slight viscosity is to increase the coefficient of discharge.

Discussion.

Mr. A. S. E. Ackermann said he had made experiments of a similar character in which the substance tested was clay. The clay was packed in a box with an orifice of from 3 to 20 mm. diameter in the bottom. The space above the clay contained air, and the pressure was raised by means of a pump.

The speaker then drew curves on the board to show his main results. With any particular orifice a certain initial pressure is required before any clay is forced out. As the pressure increases the rate of the flow becomes more rapid, and finally becomes very rapid indeed. The initial pressures and the orifice diameters were connected by the law $pd^{0.835}=5408$ for a clay with 29 per cent water. Similar results are obtained in forcing a disc through clay. The speaker mentioned that these and other results were given in a paper by him to the Society of Engineers, which was at present in the press.

Mr. Bond said the phenomena described by Mr. Ackermann were probably due to plasticity, rather than viscosity.

"Viscosity of Water and Low Rates of Shear." By A. Griffiths, D.Sc., and Constance H. Griffiths, M.Sc.

This paper describes the determination of the coefficient of viscosity of water by a method in which water is forced along glass capillary tubes of 1·5 to 2·0 mm. bore at rates of flow varying from 1 litre in two years to 1 litre in 24 years. The liquid fills a closed tubular circuit which for purposes of description may be said to be rectangular in shape. Two of the tubes of the rectangle are horizontal, and two vertical. The circulation is caused by a difference of density between the contents of the two vertical tubes. The difference is obtained by having a weak solution of uranine in one vertical tube, and pure water in the other.

In Apparatus I. the two vertical tubes are at a distance apart, and an allowance has to be made for the difference of temperature. In Apparatus II. a modification of the rectangular circuit is employed, the vertical tubes are close together, and no such correction is necessary. "Applying the temperature correction to the results recorded in this paper, the value of the co-efficient of viscosity at 18° is 0·010624 ± 0·000229 (assuming observations of equal weight), and 0·010569 gm./cm. sec. from Hosking's formula. Thus there is no experimental evidence that at the extremely low rates of shear (0·0017 to 0·0233 radians/sec.) the viscosity of air-free water in glass capillary tubes differs from its value at normal rates of shear (5000 to 10,000 radians/sec.)."

Discussion.

Dr. Vincent said it would be useful if the same apparatus could actually be used for high and low rates of shear. It would then be possible to find out any minor differences that existed better than by comparing results with different apparatus.

Dr. Rankine suggested that there was not much point in giving the results to so many figures. With regard to Dr. Vincent's suggestion it would probably be sufficient if the same capillaries were employed in conjunction with different driving apparatus for the different rates of flow, since it was in the capillaries that any errors were likely to arise. He thought, however, that the evidence of the paper was sufficient to show that there is no difference in excess of 1 or 2 per cent. This result may, of course, only hold for water.

Mr. W. N. Bond said that for viscosities as high as those used by Davidson and Kurt Molin, the viscosity changed by 50 to 100 per cent at low rates of shear.

Dr. W. Eccles said that the authors were to be congratulated on having surmounted very considerable experimental difficulties, particularly those due to temperature variations. Mr. Bond's remark suggests that with more viscous substances the range of variable viscosity is reached earlier, and this suggests that the author's next experiments should be with oils.

Dr. Griffiths, in reply to Dr. Vincent, said that in their experiments of eight years ago, in which they had been dealing with low rates of shear, though not so low as in the present experiments, they had for comparison made measurements in which the water was driven through the apparatus at ordinary rates. The difference in viscosity was less than one-third per cent in that case. With the present apparatus there would be no difficulty in geting rates of flow a hundred times greater than those dealt with in the paper.

"A Method of Measuring Frequencies." By B. S. Smith and G. F. Partridge.

An heterodyne method of measuring frequency by comparison with a calibrated valve oscillator is described. The calibration is performed by means of two valve oscillators capable of giving frequencies of, say, 1000/sec. upwards. The frequency of the oscillations is raised alternately to give a beat note whose pitch is determined by comparison with a fork. Intermediate frequencies are found by interpolation on the calibration curve and a method of checking the capacities of the oscillator condensers is described.

For the measurement of acoustic frequencies the sounds are converted into alternating currents by means of a suitable transmitter.

Discussion.

Dr. Vincent said he would like the authors to give more detail about the coupling of the middle portion of the apparatus with the end parts. The authors appeared to have reached the same conclusion as himself that a triple arrangement was most suitable for measuring frequency differences. Dr. Eccles and he had called attention to a some-

what similar apparatus which they had termed a differential wavemeter. The two outer parts generated the oscillation and the middle part resonates sufficiently to either of them that you could do anything you liked to the middle circuit without affecting the capacity, &c. With the old arrangements it was necessary for the observer to stand in a particular position and to abstain from making any movement whatever. He had only one point of criticism. He thought it was desirable to get the electricity wholesale. A different supply should be used for the two circuits. It was important to use large batteries which could be left on for some time to give steady conditions. With such precautions he thought it would be possible to get an accuracy of 3 or 4 in 10 million.

Dr. D. Owen asked to what purposes the authors had actually applied their method. Could it be used for calibrating a Galton whistle; would the sounds in this case be sufficiently intense for the method to be applicable? He presumed the authors had determined by it the limit of audibility. This was usually stated to be 40,000 vibrations per second, but he had found people who were deaf above 10,000. Could the method be used to study the overtones of a valve set?

Prof. Rankine asked if the authors could actually let us hear a note of 10,000 frequency.

Prof. Eccles said there was often some diffidence in confessing to deafness to high notes as the limit of audibility was a function of age.

Dr. Rayner said he presumed the work had been done before the Abraham Block multivibrator was described.

Mr. Partridge, in reply to the discussion, said he had seen Dr. Vincent's work, but thought he was principally concerned with the measurement of inductances. As regards coupling, the middle circuit contained the telephone and crystal rectifier in series with two small secondary coils associated with the inductances of the outer circuits; there was no tuning. As regards the electric supply, their reason for using the 220-volt lighting circuit was because of its convenience on board ship. In reply to Dr. Owen, they had found the method very useful in determining the frequency of heavily damped steel diaphragms. It would be possible to use it with a Galton whistle if some means of picking up the sound at such high frequencies was available. In reply to Dr. Rayner, he was unaware of the device he had referred to.

(Mr. Partridge then demonstrated the production of a note of 10,000 frequency. This appeared quite loud to many of the audience, but was inaudible to others).

SOCIETY OF PUBLIC ANALYSTS.

Ordinary Meeting, May 4, 1921.

Mr. Alfred Smetham, President, in the Chair.

Certificates were read for the first time in favour of Mr. W. N. Stokoe, B.Sc., A.I.C., and J. F. F. Rowland. Certificates were read for the second time in favour of Messrs. William Ellard Woolcott, and Thomas Henry Pope, B.Sc., F.I.C.

The following were elected Members of the Society: Messrs. Percy Nicholas Mould, and Walter Joseph Wright, F.I.C.

The following papers were read:—

"Detection and Estimation of Illipé Nut Fat Used as a Substitute for Cocoa Butter." By Francis C. H. Tate and John W. Pooley, B.Sc., A.I.C.

Attention is drawn to the close similarity of the various physical constants of cocoa butter and illipé nut fat, and the consequent difficulty of detection and estimation. A method is suggested involving the combination into one factor of the following constants: Densities at 60°/15·5° C. and 99°/15·5° C.; melting points in °C. of the fat and fatty acids; viscosity at 60°C.; iodine value. The combined factor is obtained by multiplying together the factors in which the average constant for cocoa butter is lower than that for illipé nut fat, the product being multiplied by the reciprocal of the only constant in which cocoa butter is the higher, *i.e.*, the iodine value. From the average multiple factors thus obtained for the two fats the composition of any mixture is calculated. For approximate estimation when only small quantities are available, a method is suggested involving the use of the melting points of the fat and the fatty acids and the iodine value.

"Notes and Demonstration on Apparatus for Determining Hydrogen Ion Concentration." By G. W. Monier Williams, O.B.E., M.C., M.A., F.I.C.

The determination of hydrogen ion concentration or absolute acidity, by the potentiometer method has not come into general use in analytical laboratories, chiefly owing to the cost of the electrical measuring instruments which are usually considered necessary. For work of the highest accuracy such apparatus is indispensable, but it is possible, for a very moderate outlay, to obtain results comparable in point of accuracy with ordinary titration methods. An apparatus of this nature was demonstrated, and the theory of the method and its application to analytical work discussed.

"A Note on the Oil of Oats." By Ernest Paul, B.Sc., A.I.C.

The author examined the petroleum ether extract obtained by extraction of whole ground oats of the variety "Black Tartary." The extract was found to contain some lecithins, and analytical constants are given for the separated oil.

"Estimation of Potassium in Presence of Sodium, Magnesium, Sulphates, and Phosphates." By H. Atkinson, B.A., A.I.C.

The method depends upon the relative solubility of these salts and the perchlorates of the metals in methyl alcohol. Potassium perchlorate has a low solubility in the liquid, while the perchlorates, sulphates, and phosphates of magnesium and sodium have a sufficiently high solubility to make the separation possible. Details of procedure are given and results of various tests.

INSTITUTE OF METALS.

May Lecture on *"The Casting of Metals."* By Prof. Thomas Turner, M.Sc., A.R.S.M.

In dealing with the subject of "The Casting of Metals," on the occasion of the Eleventh Annual

May Lecture of the Institute of Metals, on May 4, 1921, Prof. Turner stated that all metals have to be melted and cast before they are used, and that the casting of metals dated back to early antiquity. Every great nation has produced statuary in bronze; and there is no reason to believe that the quality of the older material cannot be equalled to-day, while the output has been enormously increased, and the percentage of "wasters" reduced. Among the physical properties which allow metals to be cast is viscosity, which is very low at temperatures just above the melting point, and thus metals can be poured as freely as water. Surface tension in metals is high, and this prevents them from wetting and adhering to the mould. The high co-efficient of expansion of aluminium introduces a special difficulty, and leads to fracture during cooling unless proper precautions are taken. Gases in non-ferrous metals are not so important as with steel, and any metal or alloy which does not develop gas by reaction, or does not unduly segregate, can be cast in a satisfactory manner provided that a suitable temperature is employed, that the mould is properly designed and made, and that the metal is skimmed and poured in the right manner. Pure metals of single substances, as a general rule, possess the same density whether slowly or quickly cooled. Those alloys in which there is an interval between the liquidus and solidus solidify over a temperature range and often expand when slowly cooled, as for instance, when cast in sand. Extensometer tests by Prof. Turner and his students have shown the nature and extent of such expansions in a number of typical alloys. The results of such tests agree with the density determinations, but the extensometer has the advantage of showing not merely the net result, but the sequence and amount of each volume change. In practice, one of the chief causes of failure is pouring at too high or too low a temperature. Other causes include such troubles as imperfect or badly fixed cores, faults in moulding, cracks, mis-runs or run-outs, and breakage in handling. In foundry work generally, the losses from all causes probably reaches quite 10 per cent of the output. The scientific man may introduce new ideas or processes and explain and remove difficulties. But in the end metal-casting is an art, and depends upon the skill, attention, and experience of the craftsman, who has acquired a knowledge which he may not be able to express in words, but which it is his desire to be able to impress upon the product which is the outcome of his labour.

OPTICAL SOCIETY.

At a meeting of the Optical Society held on April 14, Mr. F. TWYMAN, of Messrs. Adam Hilger, Ltd., read a paper on *"An Interferometer for Testing Camera Lenses."*

The Camera Lens Interferometer is an application to camera lens testing of the principles of an earlier instrument described in the *Philosophical Magazine* ("Interferometers for the Experimental Study of Optical Systems from the Point of View of the Wave Theory," *Phil. Mag.*, January 1918, vol. xxxv.); but it differs from the lens interferometer there described in that the camera lenses can be tested for oblique pencils.

The instrument gives aberrations in the form of an interference picture (which can be photographed), which is a contour map of the aberrations of wave front expressed in wave lengths of light in comparison with the wave front of a perfect camera lens.

A paper on *"The Testing of Heliograph Mirrors and the Measurement of Mirrors of Long Focal Lengths,"* was read by Mr. W. SHACKLETON. The method of testing the general surface consists in observing the reflection from the mirror of a system of squares on the test board, the magnification given by the mirror being utilised to determine the curvature. The method of examination is applicable to the rapid measurement of mirrors of long focal length especially of those forms silvered on the back, cata-dioptric mirrors, where the usual methods of measurement, test planes, or spherometers are inapplicable. Defects of curvature and distortion, astigmatism, and striæ in the glass can be detected, and also defects of silvering and bad polishing.

CORRESPONDENCE.

GALLIUM.

To the Editor of the Chemical News.

SIR,—In their interesting paper on gallium (CHEMICAL NEWS, 1921, cxxii., 176), T. W. Richards and S. Boyer state that the hydrogen evolved during electrolysis of a solution of crude gallium indium alloy gave a mirror in the Berzelius-Marsh apparatus, and that this deposit on spectroscopic examination showed the germanium line at $\lambda=4033$ Å.U., and a line at nearly $\lambda=4058$, probably due to lead.

With regard to the line $\lambda=4033$, the authors seem to have overlooked the possibility that this line is due to gallium itself. The visible spectrum of gallium contains the following lines (Uhler and Browning, *Am. Jour. Sci.*, 1916, xlii., 389; Eder and Valenta, "Atlas Typischen Spektren"; Dennis and Bridgman, CHEMICAL NEWS, 1919, cxviii., 245 et seq.; Bates, *ibid.*, 1920, cxx., 278, 279, 280, 281): $\lambda=3020{\cdot}61$; $4033{\cdot}18$; $4172{\cdot}22$; $5353{\cdot}81$; $5359{\cdot}8$; $6396{\cdot}99$; $6413{\cdot}92$ Å.U. The line at $4033{\cdot}18$ is remarkably close to that observed by Richards and Boyer, the more so as its intensity is given as 10 (Bates, *loc. cit.*). The reason that these authors do not attribute this line to gallium is probably that they are unaware of the existence of a gallium hydride, which has been described by Matignon (*Chem. Zeit.*, 1900, xxiv., 1062; *Compt. Rend.*, 1900, cxxxi., 891; Corrigan, CHEMICAL NEWS, 1919, cxix., 274, 275; see also *ibid.*, 1900, lxxxii., 303). This compound may have been formed by the nascent hydrogen, followed by volatilisation, and possibly subsequent decomposition of the product.

A hydride of lead has been described by M. J. Bouffort (*Journ. Soc. Chim. Ind.*, 1909, xxviii., 1126; see Corrigan, CHEMICAL NEWS, 1919, cxix., 275).—I am, &c.,

E. TOMKINSON.

6, Kitchener Street,
Barrow-in-Furness. May 4th, 1921.

NOTES.

Synthetic Resins and Varnishes.—The Electrical Research Association is actively interested in furthering the manufacture and use of electrical insulating materials made from synthetic resins and varnishes, and having the well-known heat-resisting characteristics associated with some of these materials. Leading manufacturers and users of the raw materials and finished products are already co-operating.

The election of the Rt. Hon. J. H. Whitley, M.P., as Speaker of the House of Commons has caused him to have to resign the Joint Presidency of the Industrial League and Council, which he has held for so long in conjunction with the Rt. Hon. G. H. Roberts, M.P. Members and supporters of the Industrial League and Council will be glad to know that Viscount Burnham, C.H., has graciously consented to become Joint President. Viscount Burnham has almost from the inception of the League and Council taken a keen and personal interest in its work.

Camphor Growing for Queensland.—A method of obviating the importation of camphor from Japan at high prices is suggested by Mr. E. H. F. Swain, Director of Forests in Queensland. He advises the conversion of some of the waste lands along the Queensland coast into mixed forests of kauri and camphor, capable of supplying the entire camphor requirements of the Commonwealth. The soil indicated is peculiarly suitable for both trees. The establishment of a forest products laboratory in Queensland is also advocated in order to ascertain the best methods of obtaining tannic acid from eucalyptus kinos, commercial saponins from cupanias, gum arabic from bauhinias, essential oils from citron-scented gums and citron-scented ti-trees, caoutchouc from alstonias, starch and vegetable wool from macrozamias, and resin from grass-trees, as well as power charcoal and alcohol and other derivatives of wood distillation from characteristic Queensland trees.

Finsbury Technical College.—The Governing Body of the Finsbury Technical College announce that the entrance examination for the Session 1921-22 will be held on Tuesday, September 20 next. Applications for admission should be forwarded to the College not later than September 15, on forms to be obtained from the Registrar, Leonard Street, City Road, E.C. The programme of the College is under revision, and will be issued in due course.

A Pretended Allotropic Form of Lead.—Some years ago, Heller noted that compact metallic lead, placed in contact with acid solutions of lead salts, undergoes a remarkable change after a certain time. At first it is invaded by cracks, and soon falls to powder. Heller concluded that an allotropic form of lead is produced in consequence of a phenomenon analogous to the well-known transformation of ordinary tin into grey tin. This was confirmed by Cohen and Helderman, who studied the phenomenon by aid of the dilatometer. There is no chemical reaction, according to them, and the allotropic form obtained is denser than ordinary lead. Mr. A. Thiel resumed this study and subjected the question to a profound critical examination, concluding that it is not a case of allotropy, but one of chemical action. He noted that this action only appears when the solution contains nitrate of lead, and that a well-known chemical phenomenon then occurs; dissolution of metallic lead with formation of nitrite of lead. There is a more readily attached eutectic between the crystals of metallic lead which explains the formation of cracks and pulverisation of the metal. The arguments of Thiel appear very convincing and existence of an allotropic form of lead should then be rejected.—*Revue Générale des Sciences*, January 15, 1921.

Glycol as a Glycerin Substitute.—During the war, lactates (perglycerin, percaglycerin) and glycol were utilised in Germany as substitutes for glycerin. Glycol is prepared from acetylene. It has a great resemblance to glycerin; it is more volatile and less viscuous. Fusion point—17·4° C.; boiling point, 197°; density at 0° C., 1·125; index of refraction at 20° C., 1·4723. Solubility in water, alcohol, and ether is perfectly analogous to that of glycerin. The Denigès reaction (heating with bromine water, addition, after cooling, of condensed sulphuric acid and a 50 per cent gayacol solution, blue coloration, violet in heating), gives a positive result with glycerin and glycol, but the latter does not give the Neuberg-Mandel reaction (boiling with a slightly alkaline hypochlorite solution, addition of olein and hydrochloric acid, boiling to violet or green colouration). The two substances can also be distinguished by the index of refraction. When this constant is < 1·428 it is surely glycol, and when > 1·464 glycerin.—*Matières Grasses*, February 15, 1921.

NOTES AND QUERIES.

A correspondent wishes to know of a process for recovering tin from tin scrap, and where plant for such purpose can be obtained.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

12461—Amend, O. P.—Refining petroleum distillates. April 30th.

12347—Ashcroft, E. A.—Precipitating precious metals from cyanide solutions. April 29th.

12157—Boorman, H. G. T.—Treatment of nitrates for fertilizers, etc. April 27th.

12146—Brightmore, J.—Fixation of atmospheric nitrogen. April 27th.

12129—Burgess, L.—Process of reducing aluminium oxide. April 27th.

Specification published this Week.

162026—Elmore, F. E.—Treatment of argentiferous lead-zinc sulphide ores.

Abstract Published this Week.

Alumina; Aluminium Chlorides.—Mr. S. E. Sieurin, S.E. of Hoganos, Sweden, has been granted a Patent No. 159086, in this country for an improved process of obtaining alumina by the calcination of crystals of aluminium chloride obtained by saturating a hydrochloric-acid solution of aluminous material with gaseous hydrochloric acid, the mother liquor is displaced from contact with the crystals by means of a concentrated solution of aluminium chloride, before they are removed from the saturation vessel. After the precipitation of the crystals, the aluminium chloride solution is passed from below into the vessel containing the crystals, which latter together with the aluminium-chloride solution, are withdrawn from the bottom and separated, for example, by means of centrifugal action. The hydrochloric acid is recovered from the displaced mother liquor by distilling with sulphuric acid and is used for precipitating the aluminium chloride, or is dissolved in water for the dissolution of fresh aluminous material. The sulphuric acid is concentrated for re-use and may he periodically freed from iron sulphate which is present as impurity, by cooling.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK.

Tuesday, May 24.

Royal Institution, 3. "Occultism—Its Origin and Development" by Edward Clodd.

Wednesday, May 25.

Royal Society of Arts, 4.30.
Society of Chemical Industry, 7. (At Nottingham).
Institution of Electrical Engineers, 6. (Wireless Section). Discussion on "Long Distance Wireless Transmission" opened by Mr. C. F. Elwell.

Thursday, May 26.

Royal Institution, 3. "The Architecture and Art of Hampton Court Palace" by Ernest Law.
Institution of Electrical Engineers, 6.

Friday, May 27.

Royal Institution, 9. "Elasticity" by A. Mallock.
Royal Society of Arts, 4.30.
Physical Society, 5.

Saturday, May 28.

Royal Institution, 3. "Gnosticism and the Science of Religions" by F. Legge.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

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HASELTINE, LAKE & Co., Chartered Patent Agents, 28, SOUTHAMPTON BUILDINGS, CHANCERY LANE, LONDON, W.C.

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PATENTS, TRADE MARKS. Handbook and advice free—B. T. KING, British and U. S. Regd. Patent Attorney, 146a, Queen Victoria St., London. 35 years reference

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THE CHEMICAL NEWS.

VOL. CXXII., No. 3189.

THE METALLIC HYDRIDES AND THE ACTION OF HYDROGEN ON THE METALS.

By E. TOMKINSON.

PART I.—*The Metals of the Alkaline Earths.*

THE above phenomena have been aptly summarised by J. F. Corrigan in a recent paper (CHEMICAL NEWS, 1919, cxix., 259, 273). It is the purpose of this paper to give an account of the hydrides of the alkaline earth metals, and to direct attention to certain of their applications.

Phenomena due to absorption of hydrogen, and (in some cases) to formation of hydrides are of much more frequent occurrence than might at first thought be realised. Thus we have the crystallisation and sublimation of certain metals on heating in hydrogen, the absorption of gases (principally hydrogen) in X-ray, vacuum, and spectroscopic tubes; the anomalies experienced in the spectra of metals in a hydrogen atmosphere; certain reactions in iron and steel manufacture; the adsorption theory of catalysis, and hydrogen overvoltage.

These phenomena will be dealt with in subsequent papers, and in connection with the metals calcium, barium, and strontium, we may consider the absorption of gases having a practical application, viz., in Soddy's vacuum furnace. Calcium, barium, and strontium, all combine with hydrogen on heating, forming solid hydrides of the general formula RH_2 (H. Moissan, *Bull. Soc. Chim.*, 1899, (3), xxi., 876; Guntz., *Compt. Rend.*, 1901, cxxxiii., 1209), in which the elements exhibit their normal valencies.

Calcium and Hydrogen.

Metallic calcium, on heating, absorbs all gases except the inert monatomic gases. This property has been used in Soddy's vacuum furnace (F. Soddy, *Proc. Roy. Soc.*, 1907, lxxviii., A, 429; E. C. C. Baly, "Spectroscopy," 1918, pp. 433-435; W. W. Coblentz, *Bull. U.S. Bureau of Standards*, 1914, xi., 186-187; see also Sir W. Crookes, CHEMICAL NEWS, 1919, cxix., 47) in which heated calcium is used to separate all the gases which are chemically valent, leaving only the inert gases, whose spectra are easily recognisable. If the latter are absent, an almost perfect vacuum is obtained. In this operation it is important not to heat the calcium too strongly, as, if this is done, the calcium hydride, nitride, &c., formed at a lower temperature, will be dissociated. Coblentz (*loc. cit.*, p. 186) found that combination between calcium and nitrogen, hydrogen, &c., took place at above 300° C. This investigator also noticed that by the decomposition of the hydride formed, the calcium may be sublimed up the sides of the tube in which it is heated, which phenomenon is known to occur with metals whose hydrides have not been isolated (*e.g.*, nickel). The idea of the use of calcium as an evacuator was a result of the work of Moissan (*Compt. Rend.*, 1897, cxxvii., 29, 497, 584; 1898, cxxix., 1757), and of Arndt (*Ber.*, 1904, xxxvii., 4733). Moissan used calcium to absorb the nitrogen and traces of hydrogen which are always present if a mixture of lime and magnesium powder has been used in the preliminary treatment of air for the isolation of the rare gases, and he used this method in his estimation of the argon contained in the air (finding it to be 0·931-0·938 per cent—see *Compt. Rend.*, 1903).

The Spectrum of Calcium in Hydrogen.—As a result of an investigation of the arc spectrum of magnesium in hydrogen, Fowler concluded that the spectrum observed under these conditions is that of magnesium hydride. A similar investigation was undertaken for the case of calcium by Olmsted (*Astrophys. Jour.*, 1908, xxvii., 66), who found two main groups of bands extending from $\lambda = 6404$ Å.U. to $\lambda = 6367$ Å.U. This spectrum is probably due to calcium hydride. The subject has been recently investigated by King, (A. S. King, *Astrophys. Journ.*, June, 1916) who confirms Olmsted's view. It may be mentioned as a general rule, that compounds always give band spectra, which are emitted by molecules, whilst line spectra are emitted by atoms. (*Note.*—Some elements give band spectra with feeble excitation, but line spectra with a sufficiently intense discharge, as also do monatomic elements. The banded spectrum due to calcium hydride is at a maximum between 1900° and 2200° C. The hydride would be almost completely dissociated at these temperatures (Gautier, *Compt. Rend.*, 1902, states that the alkaline earth metal hydrides are strongly dissociated at 600° C.), but it is as well to remember that (1) the hydrides may become stable at these temperatures; (2) the dissociation may be modified by the electrical conditions; and (3) a very small quantity of the hydride would give the spectrum in question. This question is also of interest in connection with the temperature of stars of the Antares type (Antarian bands), for the presence of the banded spectra of titanium oxide and magnesium and calcium hydrides in their spectra would go to show that their temperatures may be relatively low. On heating calcium in hydrogen, it takes fire and burns energetically, forming CaH_2 (Moissan).

It is of further interest to note that W. N. Hartley (*Proc. Roy. Soc. Dublin*, 1907) found certain curious effects in the spectrum of calcium in hydrogen (without a jar in circuit), finding *bands* in the orange and red. He found that at pressures of less than 5 mm., no distinct spark occurred, but there were "bright stationary spots of white light on the negative electrode, which were less bright on the positive electrode, not in one spot, but all over it." Hartley concluded that the phenomena were connected with the discharge of electricity from hot calcium and from hot lime described by F. Horton (*Proc. Roy. Soc.*, 1907). It seems to me that all the observations were due to the spectrum of calcium hydride, for the spectra were banded, and the light emission at the electrodes may well have been due to combination between the calcium and hydrogen. The question will be again discussed when we consider platinum.

The Technical Preparation of Calcium Hydride and its use for the Generation of Hydrogen for Aeronautical Purposes.—The commercial product

is known as "hydrolith," and is of some technical importance, especially for the rapid generation of hydrogen, thus: $CaH_2+2H_2O=Ca(OH)_2+2H_2$, the amount of hydrogen evolved, of course, being double that combined as CaH_2. This method of generating hydrogen has, on account of its extreme rapidity, been adopted by the French army for the filling of dirigibles. Although its cost prohibits the widespread use of this method, yet, as pointed out by Fournois (A. Fournois, "La Fabrication de l'hydrogène pour le gonflement des Ballons," *Revue Générale des Sciences pures et Appliques*, June 15, 1915, xxvi., 339), the cheapness with which the material can be transported as compared with the cost of transport of cylinders of hydrogen more than compensates for its original cost. In 1915, according to Fournois, the total cost of an outfit for 50,000 cm. was only about one-third of that of hydrogen in cylinders; one vehicle sufficing for transporting the hydrolith plant, as against tyelve for gas cylinders. A vehicle carrying six generators gives an output of 500 cubic metres per hour. The cost of the material was then 5 francs per kgrm.,, but there appears to be no demand for the substance in this country at present; at least, I have not been able to procure any.

The method for the manufacture of calcium hydride for the above purpose was patented by G. F. Jaubert in 1902 (French Patent 327,878). The hydrogen required for this purpose is obtained as a bye-product in several operations; for example, in the electrolytic production of soda from brine, and it is very necessary that it be pure. Oxygen as an impurity may give rise to explosions and causes the formation of CaO. The presence of oxygen may be avoided initially by the introduction of pierced metallic or asbestos diaphragms between the electrodes. If the hydrogen is produced by electrolysis of water, the oxygen may be absorbed by a mass of liquid zinc amalgam (in this connection, see *Amer. Chem. Jour.*, 1897, xix., 810; "Industrial Chemistry," Martin, 1918, Inorganic i., pp. 114-115; and Thorpe, "Dict. App. Chem.," 1913, iii., 60). The hydrogen in as nearly pure condition as practicable, is then passed over the calcium contained in an iron tube heated in an electric furnace.

In a later modification of this method, horizontal iron retorts filled with hydrogen are used in place of the above-mentioned iron tube (Jaubert, *Comptes Rendus*, 1906, cxlii., 788). Thus manufactured, the product contains 90 per cent CaH_2, and 1 kgrm., on treatment with water, yields a cubic metre of hydrogen, which is free from ammonia and acetylene (J. Prats-Aymerich, *Anal. Fis. Quim.*, 1907, v., 173). The 10 per cent impurity is chiefly lime and calcium nitride. According to Jaubert (*loc. cit.*), the CaH_2 was already in use in 1906 as a means of hydrogen generation for aeronautics.

Laboratory Preparation of Calcium Hydride.—Metallic calcium, contained in nickel boats, is placed in a glass tube having one end sealed and hydrogen at a pressure of 4-5 cm. of mercury is passed in, the tube and its contents being heated to redness; the temperature, however, being kept low enough to prohibit any combination between the calcium and the nickel (Thorpe, "Dict. App. Chem.," 1913, i., 599).

Properties of Calcium Hydride.—When prepared in a pure condition, calcium hydride forms a fused mass of slender transparent plates, of specific gravity=1·7, and stable in vacuo at 600°. On heating in air or oxygen, calcium hydride burns brilliantly—thus $CaH_2+O_2=CaO+H_2O$.

It is attacked by phosphorus, the halogens, and sulphur on heating (Moissan, *Comptes Rendus*, 1897, cxxvii., 29), and decomposes alcohol In most of its reactions, calcium hydride acts as a violent reducing agent, the exceptions being in some organic reactions, where condensation generally ensues.

Calcium hydride reduces many metallic oxides very easily (F. M. Perkin and L. Pratt, *Trans. Faraday Soc.*, 1907). Cupric oxide is especially easily reduced: $2CuO+CaH_2=CaO+2Cu+H_2O$, this occurring by the use of a match. Pyrolusite, tinstone, and hematite are readily reduced, but the mass must be heated in a furnace or the reaction started by means of a fuse. Zinc oxide is unreduced. Wolframite and rutile react with difficulty, whilst lead and antimony sulphides are readily reduced. Boron can be prepared from boric anhydride or from borax, and small quantities of silicon can be made from silica. It is to be noted that although wolframite is reduced with difficulty by calcium hydride, yet this is easily accomplished by metallic calcium.

Owing to the conflicting statements regarding certain reactions of calcium hydride, the subject has been recently re-examined by Reich and Serpek (*Helv. Chim. Acta*, 1920, iii., 138). A 13·2 per cent yield of formic acid is obtained by gently heating a mixture of calcium hydride with sodium carbonate or bicarbonate. According to these authors, only a small amount of ammonia is produced by the interaction of calcium hydride and nitrogen at 500°, the main reaction resulting in the formation of calcium nitride and hydrogen. Of course, the nitride could be decomposed by water (or steam), but this would certainly not be a commercial success, for then the calcium nitride could be made by the direct union of its elements, which however, is far too expensive.

$$3CaH_2+N_2=Ca_3N_2+3H_2$$
$$Ca_3N_2+6H_2O=2NH_3+3Ca(OH)_2$$

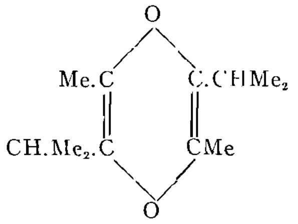
This result does not agree at all with that of Kayser French Patent, 350,966; see Chemical News, 1920, cxxi., 177), who states that the reactions are:—

$$\begin{cases} 3CaH_2+2N_2=Ca_3N_2+2NH_3 \\ Ca_3N_2+6H_2=3CaH_2+2NH_3 \end{cases}$$

in which the only material continuallly required is nitrogen. A further quantity of ammonia is available in the Ca_3N_2 (above). Moissan (*Compt. Rend.*, 1898, cxxvii., 29) stated that nitrogen had no effect on calcium hydride. It seems probable that a catalytical effect occurs, as is the case in the absorption of nitrogen by calcium carbide to give cyanamide Calcium hydride reduces carbonic oxide at a dull red heat with formation of methane, hydrogen, and formaldehyde (the latter with 16 per cent of CO).

Organic Reactions of Calcium Hydride (Reich and Serpek, *loc. cit.*).—Acetone reacts with cal-

cium hydride forming mesityl oxide (b.p. 128-130°) and



a substance of the annexed formula (b.p. 226°-231°).

With acetophenone, $C_6H_5.CO.CH_3$, at 240°, condensation products are formed. By reaction with quinoline, C_9H_7N, there is formed at 220°, *β-γ-diquinolyl,* consisting of needles, m.p. 190°.

Pyridine, at 160-165°, yields a little of a crystalline substance which is not apparently identical with any known dipyridyl (m.p. 54-56°). No action occurs at various temperatures between calcium hydride and ethyl acetate, nitrobenzene, anthraquinone, and other compounds.

On adding calcium hydride to a solution of ferric chloride in ether, a brown precipitate is produced, of the composition $Ca_3FeCl_5(C_4H_{10}O)_3$, soluble in water to an acid solution. Reich and Serpek conclude that in organic reactions, calcium hydride acts as a reducing agent only at very high temperatures, and that its use for hydrogenaiton is very limited, especially as it generally leads to condensations.

It is probable that more satisfactory results would be obtained by the use of catalysts, such as are employed in modern processes for the hydrogenation of oils.

It was proposed by Ebler (*Zeit. angew. Chem.*, xxviii., 25) to utilise calcium hydride alone or in conjunction with calcium carbide, in reducing mixed barium-radium sulphates to the sulphides (the mixture containing $CaSO_4$, $PbSO_4$, $BaSO_4$, $FeSO_4$, and 0·35 mg. radium metal per kg.); the reactions being $MSO_4+4CaH_2=MS+4CaO+H_2$—(1) or $MSO_4+4CaC_2=4CaO+MS+8C$—(2), reaction (1) occuring spontaneously, giving a reduction of 75 per cent in the low-grade material and 80·5 per cent in the high grade.

With low-grade sulphate, three parts of calcium hydride and one of calcium carbide effected a 64 per cent reduction, whilst high-grade sulphate with one part hydride to two parts carbide gave a 60 per cent reduction. But although the reactions with calcium hydride and carbide are spontaneous the cost of the latter is prohibitive (see U.S. Bureau of Mines, *Bull.* 104, 1916, pp. 71-72).

The successful commercial utilisation of calcium hydride will depend in a great measure on the cost of the metal. The production of metallic calcium in quantity is a very difficult operation, and the present position is shown in a paper by P. H. Brace ("Some Notes on Calcium"—Paper read before the Institute of Metals," March, 1921; *Engineering*, March 11, 1921, vol. cxi.).

Barium and Hydrogen.

Barium and hydrogen combine readily on heating, with formation of barium hydride, BaH_2 Guntz, (*Compt. Rend.*, 1901), the existence of which was first investigated by Winkler. It is remarkably stable, and can be slowly sublimed in a current of hydrogen at 1400° without decomposition.

On heating barium hydride in a current of nitrogen at a high temperature, it is converted into barium nitride, Ba_3N_2 (Guntz). Barium hydride possesses the curious property of still further absorbing hydrogen, but no definite hydride higher than BaH_2 is formed (Henri Gautier, *Compt. Rend.*, 1902). This phenomenon probably occurs with palladium, copper, and other metals.

Strontium and Hydrogen.

Strontium hydride, SrH_2. This compound has been investigated by Guntz (*Compt. Rend.*, 1901, cxxxiii., 1209; cxxxiv., 838) and also by Gautier (*Compt. Rend.*, 1901, cxxxiv., 100, 1108). Its chemical behaviour generally resembles that of calcium hydride, and is decomposed by water in a similar manner. $SrH_2+2H_2O=Sr(OH)_2+2H_2$.

Strontium hydride is prepared by heating strontium (prepared by electrolysis of an aqueous solution of strontium chloride with a mercury cathode, and subsequently volatilising the mercury by cautious heating), strontium amalgam, an alloy of strontium with 50 per cent of copper, or one with 55 per cent of cadmium, to a dull red heat in hydrogen, which, in the case of the alloys, is slowly absorbed and the Cd or Cu volatilises. Towards the end of the operation, the temperature is raised until the mass fuses, which occurs at a red heat. On being more strongly heated, it decomposes, its dissociation pressure being 100 mm. at 1000° C.

Like barium hydride, strontium hydride can absorb more hydrogen.

In conclusion, I think that it has been shown that the hydrides described are well worthy of further investigation, which I hope to make in the near future.

6, Kitchener Street,
Walney, Barrow-in-Furness.
15th April, 1921.

A NEW METHOD FOR THE DETECTION AND ESTIMATION OF COBALT.

By S. A. BRALEY and F. B. HOBART.

IT was noted by one of us when testing for nickel with dimethylglyoxime a brown solution always resulted when cobalt was present in the solution. This study was undertaken to determine whether this was a specific property of cobalt that might be used as a definite qualitative test and possible colorimetric quantitative method for estimating small amounts of the element.

Böttger states that "cobalt salts give with dimethylglyoxime a brown-coloured compound" (Böttger, "Qualitative Analysis," 2nd Ed., p. 212). Treadwell-Hall and Mellor both state that when determining nickel with dimethylglyoxime not more than 0·1000 grm. of cobalt should be present in 100 cc. of solution, but give no explanation (Treadwell-Hall, "Analytical Chemistry," 3rd Ed., 1913, ii., 130; Mellor, "Treatise on Quantitative Inorganic Analysis," 1913, p. 394).

Tschugaev discusses complexes of cobalt and dimethylglyoxime with pyridine and ammonia (Tschugaev, *J. Chem. Soc.*, 1914, cv., 2187), and Matsui gives a test for cobalt using dimethylglyoxime and ammonium polysulphide (Matsui,

TABLE I.—*Showing Result of Adding $NaC_2H_3O_2$ or NH_4OH and Dimethylglyoxime Solution to Some Metallic Solutions in Very Dilute Acid.*

Metal.	Colour in $NaC_2H_3O_2$ or NH_4OH solution.	On addition of dimethylglyoxime.
Nickel	No colour	Red precipitate
Iron, ferrous	Green solution or precipitate	Light red solution or precipitate
Ferric	Red solution or brown precipitate	Darkens giving red solution or precipiatte
Copper, cuprous	Blue to green solution or precipitate	Dark green to brown solution
Cupric	Dark green solution or precipitate	Brown solution or precipitate
Cobalt	No colour	Brown solution or precipitate

J. Tokyo Chem. Soc., 1918, xxxix., 459). In no case, however, is mention made that the brown colour of cobalt dimethylglyoxime solution might be used as a qualitative test.

Materials.

Kahlbaum's cobalt and nickel carbonates ("nickel free" and "cobalt-free", respectively) were carefully tested for impurities and used for all tests.

Experimental.

Qualitative Considerations.—It was first necessary to determine what metals give coloured solutions with dimethylglyoxime under the conditions of the nickel precipitation. The following table shows the results of the test in solutions containing about 0·05 mg. of the metal per cc.

If, however, mineral acid be added to any of the above solutions the colour of the metal in that particular acid prevails except in the case of cobalt in which the brown colouration remains, its intensity decreasing somewhat on the addition of the acid but depending principally upon the quantity of cobalt present. A solution containing 0·0005 mg. per cc. presents a very distinct colour. Considerable quantities of iron or copper, of course, mask the colour, but in the regular qualitative scheme these elements are removed and the filtrate resulting from the nickel confirmation gives the test directly, it being necessary only to acidify with mineral acid in order to exclude the possibility of the colour being due to slight contamination with the previously-mentioned elements.

Quantitative Considerations.—A Dubosq dipping colourimeter was used for all colourimetric comparisons.

The first procedure was to treat a solution of cobalt chloride according to the procedure for the determination of nickel with dimethylglyoxime as given in Treadwell-Hall (*loc. cit.*) with slight modification. On acidifying the resulting solution with hydrochloric acid it was found that the colour was not sufficiently constant for a quantitative comparison, although it works very well for a qualitative test. Acetic acid was then substituted for the hydrochloric acid, thus decreasing the hydrogen-ion concentration, when much better results were obtained. To reduce the hydrogen-ion concentration further sodium acetate was added to the slightly acid solution.

The actual method used was as follows. The cobalt, or cobalt and nickel, solution prepared as for the determination of nickel was slightly acidified and 10 per cent sodium acetate added until the solution was practically neutral, heated to boiling and dimethylglyoxime added in excess. (If nickel was present it was filtered off at this point.) The solution was then allowed to cool slowly and when cold comparisins were made between solutions of different strengths as standards. Because of the possible effect of excess of the dimethylglyoxime reagent or of sodium acetate these were alternately made the variable in several test solutions. Excess of sodium acetate had no effect on the accuracy while a large excess of the glyoxime reagent decreased the accuracy. This should make no difference in the determination, however, as the amount of dimethylglyoxime added in a nickel determination is based on the approximate total percentage of nickel and cobalt present, and hence a large excess of the reagent would never be present.

To show the accuracy of the results in an actual determination mixed solutions of nickel and cobalt were prepared and analysed in this way; the results are given in Table II.

TABLE II.

Ni present	Ni found	Co pres nt.	Dimethylglyoxime added (1% solution). Cc.	Co found.
0·0468	0·04664	0·00862	30	0·00822
0·0468	0·04657	0·00862	30	0·00822
0·0468	0·04662	0·00431	30	0·00383

Solution and washings diluted to 100 cc.; comparisons made with cobalt solutions containing 0·00431 g. of Co and 5 cc. of dimethylglyoxime reagent in 100 cc.

Many other results on other concentrations of the salts gave data comparable with the above.

While the method gives very good results for small amounts of cobalt in the presence of much larger amounts of nickel some points should be kept in mind. The solution or filtrate should be allowed to cool slowly as the intensity of colour seems to vary slightly with the rate of cooling and in the sodium acetate solution copper and iron must of course be absent.

Summary.

1. It has been found that dimethylglyoxime always gives a brown-coloured solution with cobalt which does not disappear upon the addition of mineral acids as does the colour of other metal glyoximes, and hence can be used as a sensitive qualitative test for cobalt, in the absence of such interfering substances as copper and iron.

2. In the absence of the elements which give coloured solutions or precipitates with sodium acetate or dimethylglyoxime (with the exception of nickel) the brown colour of cobalt dimethylglyoxime is proportional to the concentration, and hence can be used as a colourimetric method for this element, when the solution is prepared by use of acetic acid and sodium acetate.—*Journal of the American Chemical Society*, March, 1921.

THE PREPARATION OF CATGUT.

By Major F. J. W. PORTER, D.S.O., R.A.M.C.rtd., Bombay.

MANY years ago the preparation of catgut by means of iodine was hailed with satisfaction by the majority of surgeons, for it was undoubtedly a great improvement on the unsatisfactory methods then in use. It soon became obvious that the catgut prepared in this way becomes brittle after a time and it cannot be stored for long periods. For a good many years I have abandoned this method and the catgut prepared with biniodide of mercury has proved so satisfactory that I venture to bring it to the notice of those who may still be struggling with the iodine prepared material.

Very reliable catguts are now put up by various makers, but for hospitals or for surgeons who do a good deal of private practice, the cost is prohibitive.

I purchase Hartman's fat-free catgut in hanks which contain a dozen strands each about six feet in length. Each strand is coiled round the fingers into a small circle, which is held in position by winding a few turns of the end of the gut round the coil so as to keep it from becoming undone. I usually prepare about a dozen hanks at a time.

The coiled strands are put into a wide mouth bottle of about 10oz. capacity, and into it is poured enough distilled water in which two soloids of biniodide have been dissolved, so as to completely cover the gut. The solution is about 1 in 250.

The catgut swells up, and the watery biniodide penetrates into the interior and kills any spores which may be lurking there. The importance of this is obvious when one knows of cases of tetanus which have undoubtedly occurred from germs set free from the interior of catgut after the outer layers have been absorbed.

Biniodide of mercury is one of the most powerful antiseptics we possess, as the following table will show:—

Thymol	... ...	1 in 83
Boric acid	... ...	1 ,, 140
Carbolic acid	...	1 ,, 333
40 per cent Formaldehyde		1 ,, 10,000
Hydrogen peroxide		1 ,, 20,000
Mercuric chloride		1 ,, 14,300
Mercuric iodide		1 ,, 40,000

The gut is allowed to remain in this watery solution for three days.

The water is then poured off and about 3 or 4oz. of methylated spirit added to the catgut which is well shaken up. This causes a certain amount of dehydration.

This spirit is then removed and the bottle filled with methylated spirit in which two more soloids have been dissolved.

The material is ready for use after seven days, and it may be stored in the solution for years without deterioration. I wind it on glass reels according to size, and knot each strand to the next. The reel is kept in a wide-mouth ligature bottle, from which it is cut off in the required lengths at operations.

The gut is impregnated with a powerful antiseptic which does not appear to irritate the tissues. It is hard, but very pliable, and any slight accidental infection by the fingers in the act of using it may confidently be expected to be dealt with by the large amount of antiseptic which exists on the surface of the gut.

The strength of No. 1 catgut prepared in this manner must be seen to be realised, and this size is quite strong enough for the ligature of any vessel which may be encountered in an ordinary incision in any part of the body. It is of course obvious that the finer the gut which can be used for this purpose, the better the result will be.

If a more lasting gut be desired, it may be prepared in the following manner. Take some coils of catgut prepared as described above, and put them in a wide-mouth bottle. Fill it with distilled water and shake for a few minutes so as to remove some of the spirit from the outer layer of the gut. Pour this off and add distilled water to which a little formalin has been added. Leave it soaking in this for two days or longer if more durable catgut is desired. At the end of this time pour off the formalin solution, dehydrate with a little spirit, and then fill the bottle with methylated spirit in which biniodide has been dissolved in the strength as before indicated. The gut may be kept in this solution indefinitely.

No. 3 catgut prepared in this way will last in the abdominal wall for about three weeks.—*Indian Medical Record*, February, 1921.

FUEL ECONOMY AND NATIONAL PROSPERITY.

THE completion of 18 months' active existence of the Fuel Economy Committee of the Federation of British Industries, and of six months' practical work by the Technical Sub-Committee seem to offer a suitable occasion for some general report of progress and review of the outlook in the Fuel Economy Movement. For these reasons the Federation has published the present *Review*, with the co-operation of recognised authorities in the different branches. It is hoped that it will serve to bring home to those members of the Federation who have not already done so, the urgency of the need to give attention to the question of fuel efficiency each in his own works, and at the same time to emphasise the practical value of the service which the Fuel Economy Department places at their disposal.

The high cost of coal gives the fuel factor a greater importance in production policy than it has ever had before. Therein lies a danger that manufacturers may be forced into taking action without due consideration. It cannot be too strongly urged that a timely review of the whole situation and its possibilities should be made before deciding upon future programmes for securing the best results from the fuel consumed. It seems beyond dispute that henceforward no large works will be complete without a fuel control organisation as part of its regular equipment, while every industrial establishment great or small will find it necessary to instruct and encourage stokers in up-to-date firing practice, and call in expert advice on the most effective use of existing plant and test instruments.

In the pages of the *Review* an effort has been made to present the problem in a general way from the various points of view.

An account is given of the work of the Fuel Economy Department of the Federation of British Industries, describing the origin of the service,

the personnel of the Technical Sub-Committee, and the lines upon which investigation is carried out on behalf of those manufacturers who apply to the Federation for advice and help. Attached to this article is a summary of the Memorandum on Boiler Efficiency prepared by the Technical Sub-Committee, together with diagrams illustrating the losses of sensible heat in flue gases, and the principal sources of heat loss in boilers. A further article takes the form of a report on industrial fuel supplies and gives the result of the coal and coke *questionnaire* issued by the Federation of British Industries last year. The failure of a certain proportion of manufacturers receiving the *questionnaire* to co-operate by giving the particulars asked for is to be taken as a proof that much educational work still remains to be done before it can be said that British industry as a whole is alive to the importance of the fuel factor in successful production.

No name ranks higher in the scientific-industrial world than that of Sir Robert Hadfield. As the inventor of manganese steel and low-hysteresis steel, as an untiring investigator in many fields, and as the head of a great manufacturing organisation, he holds a position which may be described as unique, and his thoughtful and statesmanlike article, dealing with some leading aspects of the fuel economy movement, will not be without influence in helping to crystallise the thoughts of those who have not yet grasped the fact that the efficient use of fuel is now a vital factor in competitive manufacture.

Coming to the papers dealing specifically with the several sources of power, Mr. David Wilson brings a wide knowledge to bear on the fundamental question of coal economy as applied to steam raising. His work as technical adviser to the Coal Controller is too well known to call for comment or elaboration, and the advice which he gives, based on experience of different plants, examined during the war, when the need for economy was pressing for other reasons, cannot be neglected by the responsible heads of industry. Economy of the national coal resources by the generation of electricity of the production of gas are dealt with by Mr. J. S. Highfield and Sir Dugald Clerk, both men of the front rank in their respective spheres and needing no introduction to our readers. In his paper outlining the recent developments in the economical generation of power, Mr. P. R. Allen broadly surveys the coal resources of the world and gives use the benefit of his views on hydro-electric power and such interesting possibilities as the utilisation of the force of the waves and tides.

The thanks of all who are interested in the welfare of British industry are due to these gentlemen for their willing co-operation in making possible the publication of the *Federation of British Industries Fuel Economy Review*. Due acknowledgment must also be made to the *Iron and Coal Trades Review*, and to the Mines Department of the Board of Trade for the valuable assistance rendered by supplying statistics and information.

So far as we are aware, no publication has been issued before in this country devoted entirely to the cause of fuel efficiency and economy. In stepping into the breach the Federation of British Industries is inspired with one idea—that of helping to form and guide a healthy public opinion on the general question. Differences of view as to ways and methods there will assuredly be, but none, we venture to believe, as to the fundamental truth that close attention to these problems is vital to the success of our trade at home and abroad.

In this and in any future issues of the *Review* that may be made—it is hoped that it may be possible to produce it at quarterly or other regular intervals—the endeavour is and will be to publish the views only of those qualified by experience in the various processes which present possibilites of fuel economy. The publication of the advertisements of makers of various appliances and devices for economising fuel consumption and of patent fuels will, it is believed, render the *Review* of greater practical value to consumers, but members and others will understand that these are accepted and inserted in the ordinary course of business.

We should welcome criticisms and suggestions regarding this new venture, especially those dealing with material for further issues which, it is hoped, will focus in detail new improvements in practice and plant for power raising.—*The Federation of British Industries Fuel Economy Review*, April, 1921.

THE DEMAND FOR PATENT MEDICINES IN INDIA.

MOST LINES SALEABLE—AN INCREASING DEMAND—AN OPENING FOR MEDICINE CHESTS.

By GEORGE CECIL.

Enterprise.

WITH the growth of the white population of India, a large demand for patent medicines has arisen. Each year sees fresh manufacturing and commercial enterprises and the construction of railway lines undertaken, with the result that employment is found for managers, engineers, and foremen who are brought out from England—each of whom keeps certain patent medicines in his bungalow. Nor is the Eurasian (half-caste) element behindhand in following the example set by the "Sahib": every year they recognise more fully the necessity for having a cure on the premises, and provide themselves with various patent medicines, some of which, being of native manufacture, are of doubtful value. It will thus be seen that the demand is on the increase. For though Anglo-Indians die off from cholera, fever, and other ills peculiar to an unhealthy climate, the birth rate more than balances the mortality. The Englishman usually has his quiver full, while the half-caste's family invariably is out of all proportion to the parent's income.

Blessed by the Priests.

But it is not only amongst the Europeans and the Eurasians that the Anglo-Indian chemist finds his customers. The craze for education has spread to India, with the result that the native copies the manners and customs of the white man, even to patronising the same medicines. Thirty years ago the coloured person who suffered from rheumatism used poultices of leaves, the healing properties of which were vouched for by the priests; now-a-days he buys a bottle of something

efficacious. His father was content to suffer toothache; the son sends an order to the nearest chemist for some patent "pain-killer," taking care to explain that an imported article of European manufacture is required. In this connection, the down-to-date native has a supreme contempt for "country-made" concoctions. He imagines that the ingredients are of an inferior quality, and that though the medicine costs less, it cannot have the same effect as (what he is pleased to term) "Europe Goods." When writing his requirements, the educated native often expresses himself in an extraordinary manner, as will be seen from the following example, the original of which was written by a Mahometan schoolmaster in Lucknow :—

"Sir,—Please to send me instanter by the fellow who brings this letter a little phial of the headache pillules as you supply to the European ladies and gentlemen of the station they must be Europe Goods I am not liking native trash so please note I think they have for name phenactin bayer and the proportions must be as per accustomed thing I will pay you the cash system if you will make me the due discount and for this I will ever pray for your prosperity, and present and future offspring. Yours sincerely,

— ———, B.A. of Calcutta University

Lucknow. and etc.

Native Establishments.

Although the import business is chiefly confined to India's European chemists, there are a number of Parsee and native concerns which devote a department to drugs. Such establishments are to be found all over the country, and a fair proportion of them, especially the Parsee firms, can be trusted by the manufacturer to meet their obligations in an honourable manner. The small native concerns are less satisfactory, for the proprietors are continually in financial difficulties; their profits are cut; the outstandings are far in advance of the collections; and the only good customers in the place fight shy of them. As to the Eurasian chemists, they are practically hopeless. Starting business without the necessary amount of capital, they are too lazy and stupid to conduct their affairs in a sensible manner; and they fail to command the confidence of the English and native community, or even that of their fellow half-castes. These people are best left to the big Calcutta and Bombay wholesale chemists; being on the spot, they can satisfy themselves as to the standing of the would-be customer and arrange accordingly. But an effort might be made to do business direct with the large Parsee, Mahometan, and Hindoo chemists and general shopkeepers, who either purchase in India or indent on an East India merchant or agent—who charges them a commission. The native is a keen man of business, and readily appreciates any economy in buying.

The majority of the lines which meet with a sale at home are popular in India. Bromo seltzer, phenacetin, and caffeine tabloids, menthol, and other remedies for headaches which arise from worry, are always in demand. Beecham's Pills are as well known, and as greatly appreciated, as anywhere in Christendom; embrocation is used in eight out of ten Anglo-Indian stables; emulsion is prescribed for many a white man and woman who is the worse for a "hot weather"; and chlorodyne, liver pills, and other equally well-established remedies have a large sale. But there is no need to add to the list; it is sufficient to say that the existing demand is a large one, and that it gives every promise of increasing year by year.

Value for Money.

The manufacturer must remember that both Anglo-Indians and natives strongly resent any (supposed) attempt on the part of a chemist to get the better of them. If they buy an "instantaneous headache cure" they expect to lose the headache in five minutes! They are not satisfied with the printed instructions which provide for "another dose if necessary in half-an-hour"; they argue that the medicine professes to rid them of the headache at once, and that the chemist has "done" them. Nor is this the worst, for (having little to do and plenty of time in which to do it) they babble to their acquaintances of their woes, and do their best to give the remedy a bad name. In a few days nearly eveyone in the "station" knows that the "instantaneous headache cure" or "toothache cure," as the case may be, does not fulfil its promise—with the result that the unfortunate chemist is left with so much dead stock on his hands. This damage done by ill-chosen names and carelessly worded instructions is far greater than the reader probably imagines; it may deprive a supplier of a valuable account and seriously interfere with the sale of the article all over India.

There is also a satisfactory demand for japanned tin medicine chests, tin being preferable to leather on account of the dampness of the rainy seasons. These must be as compact and portable as possible, and should contain, say, a carefully-chosen assortment of patent medicines suitable for a country in which intermittent fever, ague, cholera, and headache are rife. Particular care must be taken to make both the medicine chest and the phials as near air-tight as possible.

It is not only in India that enquiries for patent medicines are on the increase. In Cairo, Alexandria, Port Said, Aden, Colombo, Penang, Singapore, throughout Burmah, and in fact, everywhere in the East, they have an excellent sale. This more particularly applies to the well-established articles already mentioned. But conservative though the European and native chemists are, they often recognise that the new article which they can sell at a high rate of profit is well worth the pushing necessary to make it as successful as the better-known line with which it competes.

10 Rue Châteaubriand,
Paris, VIIIe.

Societe des Ingenieurs Civils de France.—A Summer Meeting of the British Section will be held in France between June 18 and 24 next. Members of the Faraday Society desirous of taking part in this meeting are invited to communicate at once with Mr. H. Sloog, 45, Great Marlborough Street, London, W.1, from whom full particulars may be obtained.

Visit to the Rothamsted Experimental Station.—In connection with the General Discussion on Chemico-Physical Problems relating to the Soil at the Faraday Society, members and their friends are invited by the Director to visit the Rothamsted Experimental Station on June 1. A train leaves St. Pancras for Harpenden at 8.30

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, May 12, 1921.

PROF. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read:—

"The Problem of Finite Focal Depth revealed by Seisometers." By G. W. WALKER, F.R.S.

Observations of the emergence angle of P waves at Pulkovo suggest that the depth of focus is of order one-fifth of the earth's radius. It is shown that important modifications would have to be made in the interpretation of seismograms and in the attempt to determine how speed of propagation depends on depth. It is further shown that an important test of the accuracy of the Pulkovo values can be made by a careful scrutiny of seismograms for distances > 11,000 kilometres. Further progress cannot be made until this research has been carried out, and until we have corresponding measures of the angle of emergence of S waves by means of three component seisometers.

"A Liquid Oxygen Vaporiser." By E. A. GRIFFITHS.

The liquid oxygen is contained in a metal vacuum vessel. The emission of gas is governed by bringing a flexible portion of the outer wall into contact with the inner: the degree of contact determining the rate of transmission of heat across. The bottom of the outer vessel is a corrugated plate of silver, to the centre of which is soldered a copper block shaped to fit the contour of the inner vessel. The displacement of the diaphragm is controlled by a screw. Any desired rate of gas evolution can be obtained up to 10 litres per minute, and the delivery remains constant with any particular setting for several hours.

The apparatus was designed in the course of experiments carried out with the Tyndall Mining Research Studentship of the Royal Society.

"Some Experiments on the Catalytic Reduction of Ethylene to Ethane." By DOROTHY M. PALMER and W. G. PALMER.

The hydrogenation of ethylene in the presence of nickel has been quantitatively examined. The mixture of ethylene and hydrogen under investigation was brought into contact with the nickel in an electrically-heated tube, so arranged that the catalyst was in constant motion through the gas.

The rate of hydrogenation was measured by the rate at which the mixture of ethylene and hydrogen in equal proportions by volume had to be passed into the tube to maintain the gas therein at constant pressure.

The effect of varying the proportions of the two gases at constant reaction temperatures, and of varying the temperature for a reacting mixture of constant proportions were separately elucidated.

The curves showing rate of reaction against time from the beginning of the experiment show "induction" periods (during which no hydrogenation took place) varying in duration from a few seconds to many hours according to the conditions of the experiment.

At the end of this period the rate of reaction increases rapidly to a sharp maximum, and then decreases less rapidly to a lower value, which only slowly decreases with time. A theory is advanced to account for these effects.

"The Catalytic Activity of Copper."—Part II. By W. G. PALMER.

The apparatus used in the experiments and some preliminary results for which hydrogen was used to prepare the catalyst from cupric oxide were described in *Proc. Roy. Soc.*, A, lxxxix., 13.

In the present paper the activity of the catalyst when prepared from oxide by reduction with carbon monoxide and methyl alcohol vapour is described and discussed. In addition to anhydrous ethyl alcohol, constant-boiling mixtures of the following alcohols with water were used as reactants: — ethyl alcohol, *iso*-propyl alcohol, *normal*-propyl alcohol. It is shown that water acts as a positive auxiliary catalyst, and hydogen as a negative auxiliary catalyst, when adsorbed on the copper. Water may be retained on the catalyst either by absorption from a reacting alcohol-water mixture, or as the result of preparing the catalyst from oxide with hydrogen or methyl-alcohol vapour.

The activity-temperature curves for a catalyst prepared by carbon monoxide are shown to obey a simple exponential law.

Between 270° and 280° C. the activity curves (except those for *iso*-propyl alcohol as reactant) undergo a sudden change of direction corresponding to a great reduction of the temperature coefficient. This is attributed to the diminution in the thickness of the adsorbed alcohol layer to at most two molecular diameters.

The activity of the catalyst does not increase continuously, as the temperature of its preparation from oxide is lowered. This result is discussed on the basis of a theory put forward in the previous paper.

"The Total Heat of Liquid Carbonic Acid." By Prof. C. F. JENKIN and D. N. SHORTHOSE.

The paper describes the measurements, carried out for the Engineering Committee of the Food Investigation Board, of the total heat of carbonic acid between temperatures of +10° C. and +100° C. and between pressures of 900 and 1800lb. per square inch. A full table is given of the values for every 5° C. and 100lb. per square inch. The results of these measurements show that the values hitherto accepted, which are based on the assumption that the specific heat at constant volume does not change over this range, require some correction, but not to any large extent.

"The Viscosity and Molecular Dimensions of Gaseous Cyanogen." By A. O. RANKINE, D.Sc.

1. The viscosity of gaseous cyanogen has been measured at two temperatures, 15° C. and 100° C., the values obtained being, respectively, $0{\cdot}896\times10^{-4}$ and $1{\cdot}264\times10^{-4}$ C.G.S. units. Assuming Sutherland's law of temperature variation, these data have been used to calculate Sutherland's constant (C.=280) and the viscosity at 0 C. ($\eta_0=0{\cdot}935\times10^{-4}$ C.G.S. units).

2. The mean collision area of the molecule of cyanogen has been deduced, $-1{\cdot}31\times10^{-15}$ cm.^{2}, which proves to be practically the same as that of a bromide molecule $1{\cdot}28\times10^{-15}$ cm.^{2}. This is consistent with the evidence so far available from crystal examination, for the molecular volumes of KBr and KCN are nearly equal, —4·31 and 4·28 respectively.

3. If X-ray crystal examination should prove what is usually stated, viz., that KCN and KBr are strictly isomorphous, the results here obtained are consistent with the Lewis-Langmuir view that the cyanogen molecule has a size and shape nearly the same as two nitrogen molecules linked together by sharing one pair of outer electrons.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

AT the Annual General Meeting of the Society, held on April 26, 1921, the following officers and Members of Council for the session 1921-22 were elected :—

President—T. A. Coward, F.Z.S., F.E.S. *Vice-Presidents*—R. L. Taylor, F.C.S., F.I.C.; William Thomson, F.R.S.E., F.I.C.; Sir Henry A. Miers, M.A., D.Sc., F.R.S.; W. Henry Todd. *Secretaries*—H. F. Coward, D.Sc., F.I.C.; T. H. Pear, M.A., B.Sc. *Treasurer*—R. H. Clayton, B.Sc. *Librarians*—C. L. Barnes, M.A.; Wilfrid Robinson, D.Sc. *Curator*—W. W. Haldane Gee, B.Sc., M.Sc.Tech. *Other Members of the Council*—Arthur Lapworth, D.Sc., F.R.S., F.I.C.; C. E. Stromeyer, O.B.E., M.Inst.C.E., M.Inst.M.E.; W. M. Tattersall, D.Sc., Leonard E. Vlies, F.C.S., F.I.C.; F. W. Atack, M.Sc.Tech., B.Sc., F.I.C.; F. E. Weiss, D.Sc., F.R.S., F.L.S.; Francis Jones, M.Sc., F.R.S.E., F.C.S.; Laura Start, M.A.; Sydney Chapman, M.A., D.Sc., F.R.S.; and *ex-officio* the Chairman and the Secretary of the Chemical Section.

The Annual General Meeting of the Chemical Section of the Society, held on Friday, May 6, elected the following :—

Chairman—Leonard E. Vlies, F.C.S., F.I.C. *Vice-Chairman*—J. H. Lester, M.Sc., F.I.C. *Hon. Secretary*—David Cardwell, M.Sc., F.I.C. *Committee*—F. W. Atack, B.Sc., M.Sc.Tech., F.I.C.; W. H. Bentley, D.Sc., F.C.S.; Harold Moore, M.Sc.Tech., F.C.S., A.I.C.; Rona Robinson, M.Sc., A.I.C.; T. Roland Wollaston, M.Inst.Mech.E.; Edward Ardern, D.Sc., F.I.C.; R. H. Clayton, B.Sc.; J. E. Myers, O.B.E., D.Sc.; and D. M. Paul, B.Sc., A.I.C.

CORRESPONDENCE.

WATER AND ICE.

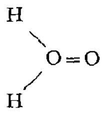
To the Editor of the Chemical News.

SIR,—I have been reading the articles on "Water and Ice" with interest. I have noticed in the Eastern Mediterranean that the shadow of the vessel on the water which in direct sunlight is a beautiful blue, is of a dark purple colour. This is due, no doubt, to slanting rays from the illuminated body, and forms part of the absorption spectrum.

As regards the colour of the sky, it seems by its purity to be due to particles which are molecular or sub-molecular in size—electrons in association with oxygen, *cp.*, the blue of ozone.

Physical properties like molecular refractions cannot give us any information regarding the degree of complexity of the water molecules for the following reason :—

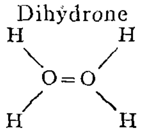
Hydrogen peroxide



o′ 1·76

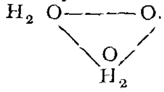
o″ 2·24

Water Dihydrone



o 1·76

Trihydrone

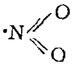


o 1·76

Unsubstituted oxygen possesses an atomic refractivity of 2·24; substituted oxygen one of 1·76. The positive hydrogen seen to absorb the unsaturation of the doubly tinted oxygen or cause a refraction of the oxygen electrons. These are the hydrones, according to H. E. Armstrong. The hydrols contain singly-linked tetravalent oxygen with an atomic refractivity of 1·76, *cp.*, the ozonides of Harries.

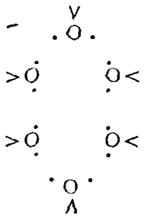
The hexacyclic formulæ for water, &c., and the conditions in hydrated copper salts, &c., also, in my opinion, exclude full tetravalent function for oxygen. According to Rooseboom's theory and observations, the various molecules of water come away in groups, the members of one group all at one temperature, which is thus like a boiling-point depending upon loose molecular association or particles under constant pressures.

These conditions resemble those for molecular associations, but not combinations, and are those for the manifestation of absorption spectra

compare 

(coloured)

There is no need to suppose the necessary want of validity of the formulæ (as such). The conditions would resemble a series (rings or otherwise) of magnets separated by an air or other dielectric space. The opposed electrons might be



the cause of the blue colour.

As is well-known, dissociation of true chemical complexes like N_2O_4, acetic acid, take place over a wide range of temperature, due, of course, to the balancing action of dissociated molecules. This balancing action does not exist in dehydrating copper sulphate, owing to the water molecules passing outside the range. In water and ice this is not possible.

It thus seems probable that the oxygen molecules are separated from each other by a shell of dielectric, and the valencies are activated, but not united, or only very loosely. It would be interest-

ing to find out how many degrees of association there may be without combination. In any case, what is the exact connotation of this term?

It is, however, evident that in copper and other salts all the water molecules are not in equal degree of association with the metallic extra valencies, thus showing the existence at different distances from the metallic centres.—I am, &c.,

GERVAISE LE BAS.

P.S.—A study of the dielectric constants, refractivities of some of the compounds mentioned might prove of value.

6, Springfield Crescent,
St. Heliers, Jersey.

SALARY OF CHEMISTS.

To the Editor of the Chemical News.

SIR,—With reference to the article which appeared in your issue of May 6, entitled "The Present Position of Chemistry and Chemists," by Prof. Wilsmore, I have written to him pointing out an error in his Address. The statement that the Research Department, Woolwich, advertised for chemists with the qualifications and at the salary mentioned in his Address is incorrect. No such advertisement was issued by that Department, which at that time was offering for chemists a much larger salary. As is well known, it has since been successful in obtaining a scale of pay for chemists which is considered satisfactory by chemists themselves.—I am, &c.,

R. ROBERTSON

29, Charlton Road,
Blackheath, S.E.2.

PAPERS RECEIVED.

"Atomic Energy and Radiation." By F. H. LORING. Received May 17, 1921.

"A Method for the Rough Estimation of Iron and Manganese in Systematic Qualitative Analysis." By L. J. CURTMAN and N. H. HECHT.

The new method which is proposed in this paper for the rough determination of iron, is based on the fact discovered by one of us (L.J.C.) that ferric thiocyanate may be bleached by a solution of $SnCl_2$. In volumetric methods for the determination of iron, the usual procedure is first to reduce the iron and then to oxidise it with a standard solution of an oxidising agent. Our method follows the reverse order: the iron, if not already in the ferric condition is first oxidised, treated with KCNS, and then reduced with a standard $SnCl_2$ solution. The results obtained by this method were so surprisingly accurate that we undertook a special study of the procedure to determine whether or not it could be used as a substitute for the standard volumetric methods. The details of this procedure, together with data showing how the new method compares with the old standard procedures will shortly be reported in another communication. In the rough estimation of manganese, the latter is oxidised by sodium bismuthate in a nitric acid solution to permanganic acid, which is then estimated volumetrically by means of a standard solution of hydrogen peroxide.

NOTES.

THEORY OF RELATIVITY.—A Lecture will be given at King's College on Thursday, June 9, at 5.15 p m. by Professor Einstein on "The Development and Present Position of the Theory of Relativity." The Chair will be taken by Viscount Haldane. A charge of 2s. 6d. will be made for admission, and the proceeds will be given to the Imperial War Relief Fund. The Lecture will be delivered in German. Tickets can be obtained on application to the Lecture Secretary.

ROYAL INSTITUTION.—On Tuesday next, May 31, at 3 o'clock, Sir James Frazer delivers the first of two lectures at the Royal Institution on (1) "Roman Life in the Time of Pliny the Younger," and (2) "London Life in the Time of Addison." On Thursday, June 2, Sir Alexander Mackenzie begins a course of two lectures on "Beethoven" (with musical illustrations), and on Saturdy, June 4, Mr. R. S. Rait gives the first of two lectures on (1) "Scotland and France" and (2) "Scott and Shakespeare." The Friday Evening Discourse on June 3 will be delivered by Dr. Leonard Huxley, Editor of the *Cornhill Magazine*, on "Chronicles of the Cornhill," and on June 10 by Dr. A. G. Webster on "Absolute Measurement of Sound." An extra Discourse will be delivered on June 17 by Sir J. J. Thomson on "Chemical Combination and the Structure of the Molecule."
a.m.

THE BRITISH ENGINEERS' ASSOCIATION.—The Annual General Meeting of the British Engineers' Association took place at 32, Victoria Street, London, S.W.1, on Thursday, May 12. At a meeting of the Council of the Association that followed, Mr. Nevile Gwynne, late Chairman of the Executive Committee, was elected President of the Association, in place of the retiring President, Col. O. C. Armstrong, D.S.O., who had occupied the position of President for three years, and to whom a very hearty vote of thanks was accorded. Mr. E. W. Petter was elected Chairman of the Executive Committee in succession to Mr. Nevile Gwynne.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

12901—Aluminium Industrie Akt.-Ges.—Process for manufacture of nitrate of calcium. May 5th.
13004—Blagden, J. W.—Manufacture of amino derivatives of hydro-genated cinchona alkaloids and their derivatives. May 6th.
12984—Frischer, H.—Apparatus for carrying out chemical and physical processes. May 6th.

Specifications published this Week.

162314—Pease, E. C.—Extraction of ammonia from gases.
138129—American Coke and Chemical Co.—Ammonia saturators.
162578—Friederick, W.—Process for the mannfacture of trinitrors rcine.

Abstract Published this Week.

Synthetic Resins.—Messrs. Vicker and The Ioco Rubber & Waterproofing Co., of Anniesland, Glasgow, has obtained a Patent No. 160258 for some improvements in the preparation of Phenol

A GREAT OFFER!

MODERN CHEMISTRY,

By ARTHUR J. HALE, B.Sc., F.I.C., F.C.S. **(PURE AND APPLIED).**

A STANDARD WORK OF ALL BRANCHES OF CHEMISTRY.

A great undertaking, a considerable task, and a heavy responsibility are involved in the publication of this work. This extensive publication demanded editorial capacity and knowledge, such as the editor and his assistants possessed, and the result represents the best achievement that could possibly be obtained by any publishing house

SCOPE OF THE WORK.

This a treatise which will be found invaluable to all who are in any way connected with the chemical industries, as well as to those concerned more closely with the scientific aspect of the subject, and it will prove a profitable and interesting source of information for all desirous of obtaining some knowledge of the subject of Chemistry as a whole, or who may be seeking for guidance regarding any particular section of the subject,

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AUTHOR AND CONTRIBUTORS.

Throughout the preparation of this work the Author has been in touch with many eminent authorities upon the different subjects treated, and with those actually engaged in the various industries a first-hand knowledge of which is essential for proper treatment. This has rendered possible a reasonable exhaustive and complete account of the industrial side of the subject.

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aldehyde condensation products. In the condensation of phenolic bodies with aldehyde compounds, the catalyst employed is a salt or double compound of hexamethylene-tetramine or mixtures of these, employed in such proportions that the quantity of hexamethylene-tetramine contained therein do‑s not exceed 2 per cent by weight of the reacting ingredients. Examples of the salts of hexamethylene-tetramine are the chloride, sulphate, acetate, tartrate, citrate, benzene sulphonate, toluene-p-sulphonate, camphorate, arsenate, trimetaborate, salicylate, sulphosalicylate, phthalate, perchlorate, chromate, sulphocyanide and tannate. Examples of the double compounds are those with phenolic bodies, such as phenol, resorcinal, pyrogallol, and guaiacol; or with halogenated compounds, such as ethyl bromide, chloral, bromine iodide, ethyl iodide, and iodoform; or with metallic salts, such as aluminium acetate, potassium antimony tartrate, sodium acetate, ferric chloride, and mercuric chloride. According to the provisional Specification, hexamethylenetetramine itself may be employed as the catalyst.

Hexamethylenetetramine Salts.—The acetate benzene sulphonate, and tuene-p-sulphonate of hexamethylenetetramine are prepared by evaporating equeous solutions of the base and the respective acids, preferably in vacuo, and purifying the products by crystallization from alcohol.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK.

Monday, May 30.

Royal Society of Arts, 8. "Industrial Disease and Immunity" by Sir Kenneth Goadby.

Tuesday, May 31.

Royal Institution, 3. "Roman Life" by Sir James Frazer.
Faraday Society, 4.30. General Discussion on "Physico-Chemical Problems relating to the Soil".
Institution of Electrical Engineers. Annual Meeting, at 5. At 6.30, "Research Work in the United States" by Dr. F. B. Jewett.

Wednesday, June 1.

Society of Public Analysts, 8. "Composition of Egg Powder" by F. F. Beach, T. E. Meade and E. Russell. "The Colorimetric Method of Determining H ion Concentration: Some Uses in the Analytical Laboratory" by Norman Evers. "Estimation of Woody Fibre in Cattle Food" by F. Robertson Dodd.

Thursday, June 2.

Royal Society, 4.30. (Bakerian Lecture). "Optical Rotatory Dispersion" by Dr. T. M. Lowry and Dr. C. P. Austin.
Chemical Society, 8.
Royal Institution, 3. "Beethoven" by Sir A. C. Mackenzie.

Friday, June 3.

Royal Institution, 9. "Chronicles of the Cornhill" by Dr. L. Huxley.

Saturday, June 4.

Royal Institution, 3. "Scotland and France" by Robert S. Rait.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

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THE CHEMICAL NEWS.

VOL. CXXII., No. 3190.

LABOUR AND DISILLUSIONMENT.

Another milestone has been reached and passed by the Industrial League; not the milestone of space, but one epoch marking in the annals of that organisation. It hove into sight, if one may so use the term, but a few weeks ago, when it was learned that the election of the Rt. Hon. J. H. Whitley, M.P., to the Speakership of the House of Commons rendered it incumbent upon him to resign the Joint Presidency of the League, and it was passed on May 19, when Viscount Burnham, the new Joint President with the Rt. Hon. G. H. Roberts, M.P., was the central figure in a happy reception held by the Executive Committee at the Eccentric Club, Ryder Street.

The dinner was presided over by the Rt. Hon. G. H. Roberts, and in addition to Viscount Burnham there were present Sir Wm. Wayland (Messrs W. A. Wayland & Co.), Sir John Prestidge (Messrs. J. Stone & Co., Ltd.), Sir Hy. Birchenough, Mr. G. J. Wardle, C.H., Mr A. Bellamy (Ex-President National Union of Railwaymen), Mr. A. Allison (Asbestos and Cable Workers' Union), Mr. Hugo Hirst (General Electric Co., Ltd.), Mr. D. Gilmour (Metalliferous Miners' Union), Mr. J. F. Green, M.P., Mr. H. Scholey (Messrs. Scholey & Co., Ltd.), Mr. H. V. Roe, Mr. W. S. Bishop (Mayor of Lambeth), Mr. E. E. Eccles and Mr. A. Jacob (British Aluminium Co.), Mr. H. S. Horne (Messrs. Read & Brigstock, Ltd), Mr. M. W. Reid (National Foremen's Association), Major A. Vigor (Messrs. A. Vigor, Ltd.), Mr. Lee Murray, Col. Meurling, Mr. J. Murrey (National Federation of Building Trade Operatives), Mr. Frank Smith (Shipbuilding Trades' Federation), &c.

The Rt. Hon. G. H. Roberts, M.P., in proposing the toast "Our Guest, Viscount Burnham", made some candid remarks relative to the industrial situation. The League felt, he said, that in securing the adhesion of Lord Burnham they were starting a new era, not to bring aggrandisement to individuals, but stability, integrity, and greater prosperity to the nation. They needed an informing and steadying influence in their midst. It was not the correct thing to give too much credence to the operations of disruptive forces in their midst, but he declared that they should not be ignored, for the Red scourge was like corrosive poison, constantly undermining our social fabric, just as the White scourge was constantly ravaging humanity. Unless they applied correctives to meet that social mischief, the whole edifice would be unable to withstand any sudden attack which might be made upon it. Since the war, strike had succeeded strike, with the result that those who pinned their faith to the Labour party found themselves now disillusioned—a disappointment and disillusionment that they would not get over within the lifetime of any of those present. The working classes of this country, unwittingly, had in the main created the evils and want that existed throughout the land. They had been misled by false leaders, and therefore, it was felt that the Industrial League was needed more than ever. They wanted the society of men like Lord Burnham, whose contribution would be helpful. The coal strike had been protracted, not because of the merits of the case, but because the miners' leaders had been afraid to tell the rank and file the truth Neither this country nor any other could uphold industries which could not maintain themselves. No industry could be definitely bolstered up simply by falling back upon the general taxation of the country. It should be the duty of leaders to educate the rank and file, otherwise they forfeited the right, if they ever had the right, to be recognised as leaders. Not only in the miners' unions, but in almost every trade union of the country, the membership was declining, and the trade union movement would, at the end of this experience, be so weakened that it would cease to be an effective force for a generation. That, to him, would be lamentable, because he believed in trade unionism. On the other hand, he also believed that employers could be successful only by operating together. The weakening of trade unionism was not the result of a conspiracy on the part of wicked capitalists. It had been wrought from within, by people who were not concerned to uplift the workers, or were not interested in the integrity and greatness of Great Britain, but who were pursuing a spurious nationalism founded on the belief that the interests of all nations were identical, and that Great Britain ought to sink back in order to allow other nations to destroy her.

Mr. Hugo Hirst, supporting the toast, congratulated the League on acquiring the services of Viscount Burnham, who, he said, had done much to alleviate distress and to bring wise counsels and compromise to bear in industrial disputes. He could not imagine a greater asset to the League than the acquisition of such assistance.

Viscount Burnham, in responding, said this League embodied the spirit of the round table—a table without sides and without corners. (Cheers) It stood for good sense, and good feeling in the industrial life of the country; it was the sworn friend of social goodwill, the sworn enemy of economic dogmas. They all felt that it was not enough to indulge in pleasant platitudes and say that they regarded the class war as the abominable thing. What they had to do was to establish the rule of reason. What we suffered from to-day was fanaticism—not on the part of the masses, but on the part of some of the leaders they blindly followed. Therefore, they should turn to account the great qualities of British character, of which loyalty was a conspicuous feature. Loyalty to a cause, or even to a great party, was always eulogised as being a civic virtue, and yet they were suffering to-day from an excess of loyalty on the part of large bodies of their fellow-countrymen to great industrial organisations which they did not wish to be charged with betraying.

Sir William Wayland proposed a vote of thanks to the Chairman, Mr. G. J. Wardle, M.H., and Sir Henry Birchenough also supported. Mr. Roberts ably responded.

A METHOD FOR THE ROUGH ESTIMATION OF IRON AND MANGANESE IN SYSTEMATIC QUALITATIVE ANALYSIS

By L. J. CURTMAN and N. H. HECHT.

Procedure.

THE Group III. precipitate consisting of the hydroxides of Al, Cr, and the sulphides of Ni, Co, Fe, Mn, and Zn is treated with 60-80 cc. of HCl (1-9) and the NiS and CoS filtered off. The filtrate containing the Al, Cr, Fe, Mn, and Zn as chlorides is carefully evaporated to 2 cc. to remove the H_2S and excess of HCl. It is then quantitatively transferred to a 50 cc. graduate, the dish rinsed several times with water and the volume in the graduate diluted with water to 50 cc. After thoroughly mixing, one-half of this solution is taken for the determination of Fe, and the other half for the estimation of Mn.

Determination of the Iron.—In a casserole treat 25 cc. of the above solution with 10 cc. 6N NaOH and 1·5 grm. Na_2O_2 Boil the mixture with constant stirring for several minutes to decompose the excess of Na_2O_2. Dilute the solution with twice its volume of water, to prevent the swelling of the filter paper, and filter. Wash the precipitate with hot water. Treat the precipitate and filter in a beaker with 50 cc. of concentrated HCl, and immediately (Note I.) heat to boiling; when solution is complete, dilute the solution and filter off the paper. Wash the filter several times with dilute HCl. In an open Erlenmeyer flask boil down the combined solution and washings to about one-half the original volume to drive off any chlorine which may be present (Note II.). Cool (Note III.) the solution to room temperature, add 5 cc. 5*N* KCNS, and titrate the solution with $SnCl_2$ solution (containing about 5 mgrms. Sn per cc (Note IV.) to a pink colour (Note V.) which matches that of a solution containing 0·05 mgrm. Fe as $FeCl_3$ in 50 cc. HCl (1 : 1) and to which 5 cc. of 5*N* KCNS have been added. Unless special provision is made to exclude the oxygen of the air, it is necessary to standardise the $SnCl_2$ solution for each determination (Note VI.). This is best done by running a definite volume of a standard solution of $FeCl_3$, oxidised Mohr salt, or ferric alum, along with the determination. The presence of manganese does not interfere with the determination.

Determination of the Manganese.—In the other half of the solution, the Fe and Mn are precipitated with NaOH and Na_2O_2, and the mixture boiled, diluted, filtered, and washed. The procedure up to this point is identical with that given for the determination of iron except with regard to the washing of the precipitate. In this case the washing must be repeated until the precipitate is free of chlorides, since the latter interfere with the final determination. In a beaker treat the precipitate and filter paper with a mixture of 25 cc. of concentrated HNO_3 and 10 cc. of 3 per cent H_2O_2, heat to boiling, and when solution is complete, dilute and filter off the filter paper. Wash the filter and boil down the combined solution and washings in an open Erlenmeyer flask to about one-half of the original volume. Cool and transfer the solution quantitatively to a 100 cc. graduated cylinder and dilute with water to the 100 cc. mark. Mix thoroughly, and take 20 cc. for the determination (Note VII.). Adjust the acidity of the 20 cc. portion by first neutralising with NH_4OH, adding 10 cc. concentrated HNO_3, and diluting the whole to 200 cc. Add 4 grms. of sodium bismuthate (Note VIII.), stir the mixture allow to settle for 5-10 minutes, and filter by decantation through a fluted filter. Wash the residue of sodium bismuthate in the beaker with 5 per cent HNO_3, and filter by decantation. The final volume will be between 250 and 300 cc. Titrate with 0·3 per cent H_2O_2 to a colourless end point. The H_2O_2 may be standardised by determining the quantity necessary to react with a definite volume of a standard $KMnO_4$ solution to which 1/4 of its volume of HNO_3 (Note IX.) has been added before adding the H_2O_2.

Notes.

I. It was found that when the mixture of $Fe(OH)_3$ and $MnO_2 \cdot XH_2O$ was allowed to remain in concentrated HCl overnight, a deep red solution was obtained even when only a small amount of Fe was present. The red colour was undoubtedly due to the Mn, for it was observed that the red colour deepened as the proportion of Mn increased. To avoid the formation of a red solution which would interfere with the subsequent determination of Fe, it is necessary to heat the mixture to boiling immediately after the addition of the HCl. Under these conditions, the colour of the solution changes from an opaque greenish black to a transparent yellow.

II. The chlorine results from the action of HCl on the hydrated manganese dioxide.

III. The solution must be cooled to room temperature, as otherwise there is danger of the $Fe(CNS)_3$ decomposing and giving a brown-coloured end point.

IV. The $SnCl_2$ solution may be prepared by dissolving 9·45 grms. $SnCl_2.2H_2O$ in 500 cc. concentrated HCl and diluting the resulting solution to a litre.

V. When attempts were made to titrate to a colourless end point, discordant results were obtained due to the difficulty of reaching the exact end point. This condition arises from the fact that the reaction proceeds very slowly as the end point is approached, and as a consequence, large intervals of time would have to be allowed between successive drops, added near the completion of the reaction, in order to determine the exact end point. Such a procedure was found impracticable. It has therefore seemed best to add the $SnCl_2$ quickly at the beginning of the titration until the solution (opaque at first) becomes transparent. When this stage has been reached, the $SnCl_2$ is added drop by drop, and the solution stirred vigorously for 10-20 seconds after each drop to determine whether the last drop has brought the end point. It was observed that solutions which had been completely titrated, slowly turned reddish on standing for from 5 to 10 minutes. This reddish colour which first formed on the surface of the solution was doubtless due to atmospheric oxidation.

It is more convenient in routine qualitative work to use for the titration of the Fe and Mn a 10 cc. graduated pipette instead of a burette.

VI. That a $SnCl_2$ solution rapidly changes owing to atmospheric oxidation is shown in the following instance. A freshly-prepared solution

of $SnCl_2$ when used as described in the method was found to be of strength 10 mg. Fe=2 cc. of $SnCl_2$. After being kept for 18 days at room temperature in a glass-stoppered volumetric flask, but with 300 cc. of air above the solution, it was again tested and found to be of strength 10 mgrms. Fe=5·8 cc. of $SnCl_2$. The solution was now only 1/3 of its original strength.

VII. An aliquot part is taken because the largest quantity of Mn that is likely to be present in 1 grm. of ore or in 0·5 grm. of an alloy is 500 mgrms. It was found that a solution of $HMnO_4$ whose Mn content exceeded 50 mgrms. in 200 cc. quickly decomposes. An aliquot part of the solution is therefore taken to make sure that the concentration is not too great. If 40 cc. are taken instead of 20, and all the quantities in the directions which follow are doubled, the final volume of the solution containing the Mn as $HMnO_4$ will be 400 instead of 200 cc. A little more than half of the solution is now filtered on a dry filter, and exactly 200 cc. of the filtrate is collected and titrated. This procedure is shorter than the one given, inasmuch as it makes unnecessary the filtration of the entire volume of the solution and the washing of the residue.

VIII. The sodium bismuthate (reagent grade) which was used was found to contain a small amount of Mn. It is therefore advisable to run a blank on a 4-grm. sample of the bismuthate in a volume of 200 cc.

IX. The presence of HNO_3 is necessary to prevent the separation of MnO_2. Pure $KMnO_4$, if accurately weighed, dissolved, and diluted in a volumetric flask, will yield a sufficiently reliable standard.

Confirmatory Experiments.

I. *The Relation between the Amounts of Iron Present and the Quantities of $SnCl_2$ used.*—Varying amounts of a standard solution of $FeCl_3$ were introduced into separate beakers. To some, 500 mgrms. of Mn as $MnCl_2$ solution were added. To each, 25 cc. of concentrated HCl were added, and the solution in each case diluted to 50 cc. After treating each solution with 5 cc. 5*N* KCNS and thoroughly mixing, the solutions were titrated with $SnCl_2$ solution to a faint pink end point. The results and other data are given in Tables I. and II.

TABLE I.

Sol. No.	Mg.Fe	Mg.Mn	c. $SnCl_2$ used.	Appearance of the solution before titration.
1	100	0	18·01	Opaque red
2	59	500	8·88	Opaque red
3	25	0	4·38	Opaque red
4	20	500	3·50	Opaque red
5	10	0	1·60	Opaque red
6	5	0	0·76	Transparent, blood red
7	1	500	0·14	Transparent, blood red

TABLE II.

Sol. No.	Mg.Fe	Mg.Mn	Cc. $SnCl_2$ used.
1 ...	1	250	0·60
2 ...	5	250	2·92
3 ...	10	250	5·80
4 ...	100	0	61·70

In the experiments of Table II., the $SnCl_2$ solution was weaker than that used in the tests given in Table I.

Conclusions.—The results in Tables I. and II. lead to the following conclusions: (1) the volume of the $SnCl_2$ used is proportional to the amount of iron present; (2) manganese does not interfere with the reaction.

II. *Determination of Mn in Pure $Mn(NO_3)_2$ Solutions.*—Different volumes of a standard $Mn(NO_3)_2$ solution were treated by the procedure given for Mn except that the preliminary precipitation with NaOH and Na_2O_2 was omitted. The results are given below in Table III.

TABLE III.

Vol. of conc. HNO_3, 10 cc. Sol. No.	Mg.Mn	Total Vol. of the Solution 200 cc. Cc. of H_2O_2 used.
1	50	30·00
2	25	14·96
3	20	12·34
4	10	6·02
5	5	2·89
6	1	0·59

The above results show that the volume of H_2O_2 used is proportional to the quantity of manganese present.

III. *Determination of Iron and Manganese by the Procedure.*—To test the relability of the proposed method for the rough estimation of iron and manganese, a number of solutions containing definite amounts of Fe and Mn were analysed by the procedure given in the first part of this paper. The results are given in Table IV.

TABLE IV.

Sol. No.	Mg.Mn	Mg Fe	Cc. H_2O_2 Used.	Cc. $SnCl_2$ Used.	Found. Mg.Mn	Found. Mg.Fe
1	500	500	26·97	16·18	506	508·6
2	250	50	14·60	1·61	273	50
3	300	100	16·19	3·10	303·7	97·6
4	100	0	53·30	—	For standardisation of H_2O_2	
5	0	100	—	6·35	For standardisation of $SnCl_2$	

Comments.—In making the calculations it is necessary in accordance with the procedure, to multiply the quantities of $SnCl_2$ used by 2, and the figures for H_2O_2 by 10. Experiment 4 supplies the data for the calculation of the strength of the H_2O_2 in terms of Mn; while the strength of the $SnCl_2$ in terms of Fe may be readily calculated from the figures in experiment 5. The results in the last column show that the method supplies a relable means of roughly estimating the amounts of manganese and iron in systematic qualitative analysis.

Summary.

1. A rapid method is proposed for the rough estimation of iron and manganese in systematic qualitative analysis.

2. The estimation of the iron is based on the property of $SnCl_2$ to bleach the deep red $Fe(CNS)_3$, formed by adding KCNS to the $FeCl_3$ solution.

3. The manganese is converted by sodium bismuthate in nitric acid solution to $HMnO_4$, and the latter bleached by the use of a standard solution of H_2O_2.

4. Since the presence of either metal does not interfere with the determination of the other, it is unnecessary to effect their separation in this method.

5. Test analyses show that the method is trustworthy.

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THE PURIFICATION AND SOME PHYSICAL PROPERTIES OF CERTAIN ALIPHATIC ALCOHOLS.

By ROGER F. BRUNEL, J. L. CRENSHAW and ELISE TOBIN.

We have found it necessary to prepare in this laboratory a series of aliphatic alcohols, in which there should be, if possible, no impurity exceeding 0·1 to 0·2 per cent, and have undertaken to purify these alcohols by a somewhat more careful fractional distillation than is usually carried out.

A little examination of the literature will show that there is no criterion for the purity of any except a few of these simple substances. Except in the cases of methyl and ethyl alcohols agreement in boiling points to 0·1° and in densities beyond the third decimal is unusual. (Michael, Scharf, and Voigt (*Jour. Amer. Chem. Soc.*, 1916, xxxviii., 653); purified *iso*-butyl alcohol with great care, and Orton and Jones (*J. Chem. Soc.*, 1919, cxv., 1194), *n*-butyl alcohol, but the physical properties are not recorded. *Tertiary* butyl alcohol, by reason of its high melting point, has also probably been obtained pure.) Since the chief criterion of purity of our own products is in the data obtained in the distillation it appears necessary to enter into some detail with regard to the stills used, and even more, with regard to the fractions actually obtained, particularly since most common organic compounds have already been fractionated "with great care" by various investigators.

Method of Distillation.—The stills most used have been brass tubes (pyrex columns of the same height and 36 mm. in diameter have occasionally been used). 1·8 meters tall and 30 mm. in diameter, filled with quartz pebbles which pass through 4-mesh, but not 5-mesh wire netting. These pebbles, obtained under the name of Long Island grit, were cleansed with *aqua regia*, and all markedly pitted or flattened pebbles were picked out.

With alcohols boiling above about 80°, the condensation in such a column, even when wrapped with asbestos, is so great that the vapour can be driven up through it only with difficulty. The columns are therefore wound with resistance wire (a winding with Advance (constantan) wire, No. 21 gauge from the Driver-Harris Wire Co., six turns to the inch, is satisfactory with the 110 v. current) upon a layer of asbestos, and sufficient current is sent through to overcome some of the loss of heat to the air and keep the distillation in progress with a flame 3 or 4 inches high under the flask at the bottom. Alcohols boiling as high as 130° have thus been distilled. Furthermore, by connecting the heating coil to the 220 v. circuit at the end of the distillation, the column can be heated as hot as desired, and the liquid retained by the pebbles greatly reduced, usually to about 30 cc. Towards the end of this process the fractionating effect is, of course, diminished, but when the alcohol is pure, no change in temperature occurs until the liquid is nearly out of the column, when super-heating becomes markedly evident. This point is so well marked that there is never any doubt as to when it is reached.

The effectiveness of the stills is, of course, greater, the slower the rate of distillation. The rate is followed by observing the drops from the end of the adapter on the condenser. The speed of distillation rarely exceeds 40 drops a minute, and during the last few distillations of a pure product it is kept at 15 to 30 drops a minute. With a pure substance the temperature of the vapour should, of course, be independent of the rate of distillation, and this was found to be the case with a five-fold change in the rate with *iso*-propyl and *iso*-butyl alcohols. It appeared to be the case for all of the alcohols with the small changes in rate which inevitably occur.

The temperatures are read on thermometers graduated to 0·1°. With our tall stills it is impracticable to use a cathetometer, but a special reading device, magnifying five diameters, is supported against the still head in such a way that perpendicular vision is obtained, and errors due to parallax are avoided. (A brass tube, 15 cm. long, with support to fit the still head, is fitted with a Bausch and Lomb 25 mm. triple aplanat lens as objective and a brass cap with 1·5 mm. hole as eyepiece. This device, in improved form, is now offered for sale by the A. H. Thomas Co., of Philadelphia). The temperature is always read to 0·01°, and the barometer read simultaneously. *When products are spoken of as constant boiling, constancy to 0·01°, as nearly as can be read, is to be understood.*

The thermometer is enclosed in a glass still head at the top of the column, 20 mm. in diameter, and tall enough so that the thermometer can be suspended completely in the vapour. A wire ring prevents contact with the walls. (The thermometer bulb was thus far below the side arm, but there is no reason to expect change of composition of the vapour in ascending the glass tube above such a tall column, except with impure substances and a device such as that of Richards and Barry (*Jour. Amer. Chem. Soc.*, 1914, xxxvi, 1787) appeared necessary). The immersion of the entire thermometer in the vapour is of the greatest importance with thermometers which are not gas-filled. If only the mercury stem is immersed, enough mercury distills and condenses further up the capillary to cause serious error in a short time (Olivier, *C.A.*, 1917, xi., 1927, has observed such vaporisation of the mercury in a thermostat at 30°). The bulb of the thermometer is protected from radiation by black paper around the glass. If there is any difference between the effect of such a shield and one of nickel or iron inside the still head, it is a matter of less than 0·005° at the temperatures here concerned. The chief purpose which the shield serves is to provide protection from radiation from nearby lights, which may raise the temperature of the thermometer some hundredths of a degree.

Our stills are sufficiently effective so that in many cases we obtain a considerable quantity of distillate within 0·01° after one or two distillations, but it is, of course, a more difficult matter to obtain products which will redistil entirely, or nearly entirely, at constant temperature.

The extent to which a constant boiling fraction finally again comes over at constant temperature is what we have taken as the chief criterion of purity. Statements that "nearly all" of a product distils constantly appear so inexact that we have given below the boiling-point range and weight of the fractions in many of the final distillations,

and in all cases the percentage of the product collected without change of temperature.

Sometimes nearly the whole amount distils at constant temperature, but we have usually had to be satisfied when 70 to 80 per cent, and in a few cases even less of a product collected at constant temperature would again come over at the same temperature. In such cases the deviation from constancy has not been great. The distillation rarely begins more than 0·15° below the true boiling point, and frequently only a few drops come over so low. Sometimes the low boiling portions are all within 0·05 or even 0·2°. The temperature at which the distillation begins can well be determined since the hot vapour is at first driven up through the still head slowly, and the thermometer is deeply enough immersed to assume the temperature of the vapour before any passes over.

Since the temperature in the final distillations, when it has once become constant, always remains constant until the distillation ceases, it is evident that high boiling impurities are retained in the still, if they have not been already eliminated in the liquid retained by the still in earlier distillations. In the case of *iso*-propyl and *iso*-butyl alcohols the residues from distillation of a number of nearly pure specimens were united and subjected to further fractionation. Since these residues yielded, with very little further fractionation, specimens which did not differ in density or refractivity from the main products, it appears that high-boiling impurities were probably eliminated early in the process of fractionation.

The exact determination of the boiling points of the alcohols was a matter of difficulty. At first the final distillation of each alcohol was carried out with a still head containing three or four thermometers. When the corrections were obtained for the thermometers the boiling-point readings agreed within 0·02° at temperatures below 100°, but above 100° no satisfactory results were obtained. Through the courtesy of the Bureau of Standards, it was then arranged that we should take specimens of the alcohols to the Bureau and determine their boiling points with a resistance thermometer. Here it was found that with small specimens of the alcohols in a boiling point apparatus no constant readings could be obtained when the violence of the boiling was altered. In particular, with the higher boiling alcohols the temperature always fell as the violence of boiling was increased. We were not in a position to continue the work there long enough to discover whether the cause of the difficulty lay in the alcohols or in the design of the boiling-point apparatus.

In order to continue the work in our own laboratory, since we were equipped with a potentiometer, a thermoelement was employed.

The Thermoelement.—A 12-junction copper-constantan thermoelement was constructed materially according to the directions of Adams (*Jour. Amer. Chem. Soc.*, 1915, xxxvii., 484), of No. 36 copper and No. 30 constantan ("Ideal" wire from the Electrical Alloys Co., of Morristown, N.J., was used), B. & S. gauge. The constantan wire was tested for homogeneity in order to have as small electromotive forces as possible set up at points other than the junctions, and a good deal of wire was rejected. Twelve 120 cm. lengths were selected with 30 cm. at one end and 25 cm. at the other as homogeneous as possible, the former ends being used for the hot junction. Satisfactory junctions were not obtained with ordinary solder, so they were brazed with silver solder in a small flame, with borax as flux. They were then dipped in enamel obtained from a wire insulating company, which was hardened by heating at 230°. The sets of hot and cold junctions were enclosed in glass tubes connected by rubber tubing.

A Leeds and Northrup potentiometer was used, but the coils were first tested, since we wished an accuracy of 1 microvolt in 70,000. No corrections of more than 5 μv. were found necessary.

Three Clark cells and two sets of 5 Weston cells served as standards (Hulett's directions were followed, *Phys. Rev.*, 1911, xxxii., 257). These were kept in a thermostat at 24·94° ±0·005°. The Clark cells differed by only 0·00004 v. almost from the start, and the relation between them within this range remained almost constant. When the Weston cells became constant, they also remained nearly as close together. The ratio between the Weston and Clark cells has remained exactly that found by Guthe (*Guthe*, Bur. Standards, *Bull.* 2, 1906, 33) and Hulett (Hulett, *Phys. Rev.*, 1911, xxxii., 276), $\frac{1·0184}{1·42040}$ at 25°, for several months.

The calibration data for the thermoelement were as follows. Cold junction at 0°. $Na_2SO_4.10H_2O$, transition point 32·384° (Dickinson and Mueller, *Jour. Amer. Chem. Soc.*, 1907, xxix., 1381), 15,779 μv. $SrCl_2.6H_2O$, transition point, 61·341° Richards and Yngve, *ibid.*, 1918, xl., 89), 30,814 μv. Water boiling point, 52,127 μv. at 760 mm. Naphthalene boiling point, 217·58° at 753·4 mm. (Jaquerod and Wassner, *J. Chem. Phys.*, 1904, ii., 52), 12,4459 μv.

These values do not fall on a curve, which can be represented by three constants. The three higher values have, therefore, been used, giving the equation,

$$E = 470·045t + 0·54892t^2 - 0·00042t^3$$

which does not differ greatly from that of White (White, *Phys. Rev.*, 1910, xxxi., 162), or that of Adams and Johnston (Adams and Johnston, *Am. J. Sci.*, [4] 1912, xxxiii., 538).

The value calculated for the transition point of sodium sulphate from our equation is 15,785, instead of 15,779 found. This corresponds to an error of nearly 0·01°, but we are using the element in the temperature range 78-130°, and our equation probably does not introduce an appreciable error there. (The equation recommended by Adams (*J. Wash. Acad. Sci.*, 1913, iii., 469, $E = At + B(1 - e^{-Ct})$ would very likely prove more satisfactory, but we have not, up to the present, had the necessary table of exponentials at hand).

The increase in e. m. f. per degree varies from 551 μv. at 77° to 654 μv. at 217°. Since it is readily read to 1 μv., the thermoelement is evidently sensitive to 0·002°. In fact, a change of 0·5 μv. is noticeable on the potentiometer. Although we believe that the boiling point of water is reproduced to better than 0·01°, such accuracy has not been obtainable with the alcohols, but most of these are probably correct to ± 0·01°.

The thermoelement is inferior to the resistance

thermometer for the determination of boiling points unless an instrument can be made which is independent of the depth of immersion in the hot vapour. In spite of our care in choice of the constantan wire, the e. m. f. varied with the depth of immersion as much as 8 μv. at 100°, the greatest error occurring when just the tip was heated. But it was found that there was a range of about 7 cm. over which there was no change, and there was only about 3 μv. variation in the immediate neighbourhood of this region. The element was therefore used with an immersion of about 14 cm. with the possibility of varying this several cm. either way without altering the reading. (With naphthalene there was variation in the reading even within this best portion of the element. The calibration value was read with what we considered our standard depth of immersion).

A nickel or iron shield has been used about the thermoelement. We have not detected any difference between them. A piece of black paper outside the tube has the same effect to within 0·005°. The effect of omitting the shield depends mainly upon the surroundings, the thermoelement being sensitive to changes in the illumination of the room, such as the lowering of a shade in a window some distance away, or switching lights on or off within a metre or two of the apparatus.

(To be continued).

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, May 26, 1921.

Prof. C. S. Sherrington, President, in the Chair.

The following papers were read :—

"The Atomic Process in Ferro-magnetic Induction." By Sir Alfred Ewing, K.C.B., F.R.S.

The author refers to his paper published by the Royal Society in 1890, which modified Weber's theory of the magnetisation of ferro-magnetic substances by showing that the control exerted on each elementary magnet by its neighbours was competent to explain the phenomena of susceptibility and hysteresis. In the present paper this theory is reconsidered in the light of (1) modern views regarding the structure of the atom, and (2) the X-ray analysis of crystal structure by Sir W. H. and Prof. W. L. Bragg. From the results of that analysis it appears that the rotatable Weber magnet is an attribute of the atom, not of the chemical molecule. It is not the atom itself, but probably an electron system within the atom. Metallic iron is now known to be an aggregate of crystals in each of which the space-lattice is the centred cube, with its atoms most closely grouped along the triagonal axes. It is along these axes that the Weber elements will point. Consequently an iron crystal is not magnetically isotropic.

An important characteristic of the magnetising process in iron is that there is a small quasi-elastic or reversible part preceding the much larger changes which involve hysterisis. This corresponds to a reversible deflection of the Weber magnets through a small angle, generally of an order of 1° or less. The theory of the equilibrium of a row of magnets is considered, and experiments are described in which rows of Robison magnets with ball ends have their equilibrium upset by an extraneous field. The results of these experiments confirm the theory. From the known value of the magnetism of saturation, the moment of a single Weber element is estimated, and the field is calculated which would break up rows of magnets, set in the space-lattice close enough together to bring the reversible deflection within the above limit. The field so calculated is far larger than the field that suffices to produce strong magnetisation in iron, which suggests that the ordinary laws of force between magnetic elements cease to apply at interatomic distances.

'The Magnetic Spectrum of the β-Rays excited by the γ-Rays." By C. D. Ellis.

The magnetic spectra of the β-rays ejected from various elements by the γ-rays of radium B have been examined by the focussing method used by Rutherford and others. The positions of three strong lines occurring in the magnetic spectrum of radium B are found to depend on the metal target used. Assuming that each of these three lines is due to a definite γ-radiation, it is shown, for all the elements examined, that the energy of the β-rays forming a line is equal to an energy characteristic of the γ-radiation minus the work necessary to remove an electron from the K ring of the atom. By application of the quantum theory the frequency of the γ-rays can be determined from these characteristic energies. The natural β-ray spectrum of radium B can be explained in this way, the stronger lines resulting from the conversion of the γ-rays in the K ring, and the weaker lines from a similar conversion of the same γ-rays in the L ring.

"The Spectra of the Alkaline Earth Fluorides and their Relation to each other." By S. Datta.

The present paper gives an account of an investigation undertaken to determine possible relations among the band spectra of similar compounds of different elements. Previous work by other observers suggested the alkaline earth fluorides as a suitable group of compounds for this purpose. A more complete survey of the spectra of these compounds has been made and several new bands observed. These helped in the identification of homologous series of bands in the different spectra and have suggested an empirical relation amongst them, based on the constants of the series equations and the molecular weight or the molecular number of the respective compounds.

Starting with the series equation of the band heads, a probable explanation has been given of the appearance of a "tail" in some of the bands. It has further been shown that the frequency of the tail is either a maximum or minimum, and that the difference in wave numbers of the heads and tails of the similar series is constant for the same compound, but varies from one another in a definite way.

"A Simple Apparatus for Approximate Harmonic Analysis and for Periodicity Measurements." By W. L. Balls, Sc.D.

An account is given of a simple and inexpensive means for constructing and using an apparatus by which periodicities can be determined, harmonic analysis effected, and curves smoothed.

The results obtained (both with respect to length and to amplitude) are only approximately correct, but the error involved need not exceed three per cent.

The outstanding advantage of the apparatus is the speed with which determinations can be made. Thus, in the case of determinations of periodicity, some fifty trial periods can be examined in less time than is required for the computation of a single trial period under the periodogram arithmetical method.

"The Influence of Satellites upon the Form of Saturn's Ring." By G. R. Goldsbrough, D.Sc.

Following upon the well-known results obtained by Maxwell that the only form of ring about a planet consistent with stability must be one made up of particles sufficiently small, this paper examines the perturbing effect of a satellite upon such a ring.

The ring is supposed to be made up of small particles—not necessarily equal—arranged in concentric circles and rotating about the primary. The satellite is assumed to follow an unperturbed circular orbit, and as a sufficient approximation, the influence of the rings upon one another is assumed negligible.

It is then shown that to a close degree of numerical approximation the satellite Mimas is responsible for the position and width of Cassini's Division and for the clean-cut termination of the whole ring. Satellite Rhea accounts for the clean-cut commencement of the inner ring (or Ring B), while a probable explanation is offered of the existence of the Crêpe Ring.

The numerical values obtained are as follows :—

	Calculated	Observed
Commencement of Crêpe Ring	9·34″	10·83″
,, Inner Ring	13·07″	13·21″
Dimensions of Cassini's Division	16·9″	16·87″
,, ,, Assumed	17·64″	17·64″
Termination of Ring ...	20·2″	20·01″

If m be the mass of any particle, and M the mass of Saturn, and n the number of particles in any single ring, then it is shown that :—

$$0 < \frac{m}{M} < \frac{1\cdot 8}{n^3}.$$

The maximum mass of a particle is thus just below the limit given by Maxwell. The inclusion of the mutual influence of the rings and the effect of the oblateness of Saturn would probably improve the agreement of theory and observation.

"Certain Geological Effects of the Cooling of the Earth." By H. Jeffreys, D.Sc.

The paper deals with certain mechanical consequences of the cooling of the earth from its formation to its present state. The former fluidity of the earth is assumed for reasons given, and the information provided by radioactivity is utilised. It is found that the thermal contraction available for mountain-building is of the same order as that required to account for existing mountains. The Pacific type of mountain range can apparently be explained as a consequence of the greater cooling and consequently greater strength of the rocks below the ocean. Isostatic compensation of surface inequalities is considered due to variation in the thickness of the light rocks constituting the crust, combined with plastic flow below. On these lines the main phenomena of isostasy can be accounted for. The fact that oceans have extensive regions of less depth in the middle is explained on this theory. Theories of the formation of continents and geosynclines are suggested.

"The Moving Striations in a Neon Tube." By T. Kikuchi.

PHYSICAL SOCIETY.

May 13, 1921.

Sir William Bragg, F.R.S., President,
in the Chair.

The following papers were read :—

"Notes on Vacuum Tubes used as Detectors of Electrical Oscillations." By Messrs. Hartshorn and E. S. Keeping.

I. The paper describes the development of a robust form of vacuum tube which was used as a detector of electrical oscillations in the "wireless" circuits carried by aeroplanes. Platinum electrodes are avoided, being replaced by strips of tinfoil, to which contact may be made by the spring clips holding the tube in position.

II. It was found that when a discharge is passed through such a tube, the walls are affected in such a way that thenceforth it is much easier to get a discharge to pass. The change produced by the first discharge is annulled by heating the tube above 210° C. Further, if the walls are coated on the inside with a metallic film, this first discharge is unnecessary, and the tube is unaffected by heating, but when the walls are coated with an insulator it is if anything more difficult to pass a discharge. A silica tube behaves like one coated with metal. It seems possible that the change in the tube may be due to the formation of a layer of gas molecules on the walls by the first discharge. The explanation of the behaviour of the silica tube is a difficulty.

Discussion.

Prof. G. W. O. Howe mentioned that comparisons of vacuum tube detectors both with internal and external electrodes were carried out at the Reichsanstalt. Helium at various pressures was employed. Certain pressures were used to obtain extreme sensitiveness, while others were used if extreme brightness was desired. In some of the tubes issued internal electrodes were fitted, not for actual use, but for the initial preparation of the tube by electrolytic deposition of potassium on the walls.

Dr. Vincent hoped the authors would not cease work on this interesting problem with the publication of the present paper. They had dealt only with one aspect so far, but there were a number of interesting researches, particularly in connection with valve-maintained circuits, which would suggest themselves. Mr. Hartshorn had mentioned the advantage possessed by the method that

it responded without lag during quick tuning. Another advantage was that there was no rectification of the current.

Mr. G. D. West asked if many of the authors' results in connection with the initial hardness of the tubes and the permanent softening effect of an initial discharge could not be accounted for by minute perforations of the walls by the discharge? The effects of subsequent heating appeared to fit in with this hypothesis.

Mr. W. R. Cooper asked whether the authors had looked up the work of Claude on neon tubes. These were large tubes for illumination, and it was found that a tube 6 metres long required less than 800 volts. Possibly some of the effects observed by the authors (*e.g.*, on heating the tubes), were due to the fact that the slightest impurity produced a marked effect. Claude found that it was not sufficient to use pure neon; he therefore purified the neon when in the tube itself by connecting the tube to a receiver containing carbon and immersed in liquid air.

Dr. Borns asked if a film of moisture might give rise to any of the effects?

A Visitor said that a common form of indicator in use for tuning purposes was an ordinary flash-lamp bulb. What were the conditions necessitating the use of vacuum tubes? He noticed that when responding to spark discharge it was difficult to note the brightest point on account of the intermittence of the light. This flicker is absent with a flash-lamp. The response of such bulbs was also quite quick enough for all ordinary conditions. Would a fluorescent screen in the tube increase its efficiency? What was the effect of the frequency of the oscillations on the voltage necessary for discharge?

Mr. Hartshorn, in reply, said he was not familiar with all the early work which had been mentioned. They had assumed that the experts who had referred the problem to them were aware of all that had been done on it. He did not think perforations would explain the softening of the tubes, as this would not fit in with the behaviour of some of the compound tubes. As regards moisture, the greatest care was always taken to exclude this. As regards the use of vacuum tubes it was essential that the signals should be easily seen on an aeroplane, and flash-lamp bulbs required more careful watching. As regards the intermittence, this was certainly a drawback, but was only present with spark discharges. It was not there with valve circuits. A fluorescent screen would make the tubes much too difficult to construct. Something very simple and robust was required. He did not know the effect of frequency on the discharge voltage. The figure he gave, 260 volts, was at ordinary supply frequency.

"*The Coefficient of Diffusion of certain Saturated Solutions.*" By Mr. B. W. Clack, M.Sc.

This paper gives an account of experiments on the Diffusivity of saturated solutions of KCl, NaCl and KNO^3 at constant temperatures near 18° C., when the steady state of diffusion has been attained, employing a method similar to that previously used by the author (*Proc. Phys. Soc.*, 1908, xxi., 863; 1911, xxiv., 40; 1914, xxvii., 56; 1916, xxix, 49).

The solution under investigation is maintained at complete saturation by the presence of salt crystals in the diffusion vessel, the theory takes into account the change in volume of this salt as it dissolves, and an expression is obtained for the coefficient of diffusion at complete saturation, which depends on the rate of change in weight of the diffusion vessel with time. The experimental results are found to agree very closely with the values obtained by extrapolation from the results previously found for less concentrated solutions. By the present paper the author has thus extended the range of concentration over which he has studied diffusion from very dilute solutions right up to complete saturation.

Discussion.

Dr. A. Griffiths dealt with the fundamental expression for diffusion. He explained the theoretical foundation of the diffusion-equation used by Mr. Clack and himself, and stated that this equation was an extension of Fick's Equation, or that Ficks' Equation could be considered to be a limiting case of their equation. He said that Fick's Equation implicitly assumes that the liquid is at rest during a diffusion operation, whereas in fact the changes in concentration in all experiments known to himself inevitably produce movement of the liquid. An extension of Fick's hypothesis is, therefore, inevitable. He explained that the equation used by Clack and himself assumed that in addition to the diffusion as expressed by Ficks, there is a movement of the diffusing salt equal in value to that of the water-component of the salt solution. He stated that the quantity defined by δ in earlier papers by Clack and himself should have been defined as the ratio of the *mass* of water entering the diffusing cell to the mass of water leaving the cell. The modification of the definition makes no change whatever when a linear relation may be assumed between density and concentration; and, in any case, makes a change smaller than errors of experiment. The change becomes smaller with the concentration, and is zero at infinite dilution.

The coefficients of diffusion for the weakest solutions of potassium and of sodium chloride were each 16 per cent less than the theoretical values given by the Nernst-equation for infinitely dilute solutions. The value of the coefficient for potassium nitrate was 11 per cent less than the theoretical. These differences could not be considered very remarkable if it were remembered that Perrin's value (based on work with liquids) for the electronic charge was 11 per cent less than the generally accepted value. The fundamental hypothesis for liquids probably require a close examination. One of his students had interpreted Mr. Clack's results by the equation $K = K_1 + K_2(1 - r)$, where K is the coefficient obtained by Mr. Clack, K_1 is the coefficient of diffusion of the completely ionised salt, K_2 is the coefficient of diffusion of the non-ionised salt, and r is the ionisation ratio. In the case of potassium nitrate this equation represents the results obtained by Mr. Clack wonderfully well over the whole range of concentration, and it represents the results well in the case of potassium chloride and of sodium chloride when the concentrations are not great.

Capt C. W. Hume did not think the concentration at the top of the diffusion tube would be zero. The effect of this error would be equivalent to a constant increase in the length of the tube.

Mr. F. E. Smith asked if experiments could not be made by measuring differences in electrical conductivity. Such methods, it appeared to him, would enable results to be obtained much more rapidly.

Mr. Clack, in reply, said that earlier in his researches he had investigated the end-correction suggested by Mr. Hume and concluded that it was negligible. As regards the conductivity method, this

had been tried, but he was at present experimenting with an optical method with which it should be possible to obtain results for all concentrations in one experiment.

"*Experiments on Thermal Transpiration Currents.*" By Dr. G. D. WEST.

This paper is an attempt to demonstrate the actual existence of thermal transpiration currents. Theoretical considerations are first introduced to show that if a radial temperature gradient be maintained over a disc, so that the centre is the hottest part, thermal transpiration currents sweep radially inwards over the surface of the disc, and discharge themselves more or less radially outwards in the upper regions.

To detect these currents a narrow strip of foil is used which is placed perpendicular to the disc, and to one side of the hot region. When at a considerable perpendicular distance from the disc, and when the gas pressure is sufficiently low to eliminate convection currents, the deflections of the strip of foil are always away from the hot region. When, however, the strip is placed very close to the disc, its deflections over a certain range of gas pressure are towards the hot region. These facts are explained by the tendency of the thermal transpiration currents to drag the strip with them.

The paper emphasises one of the essential differences between thermal transpiration currents and convection currents—namely, that while the latter clearly depend on gravitation, the former do not. Further emphasis is laid on the differences between the conditions of molar and molecular equilibrium.

DISCUSSION.

Dr. D. OWEN said the author appeared to be working down to pressures of a ten-thousandth of a centimeter of mercury. How were these pressures measured?

Dr. WEST: With a McLeod gauge.

Dr. OWEN then asked if the author considered these to be reliable at such low pressures?

Dr. WEST replied that he always used two gauges and they gave similar results. The bulbs were from 200 c.c. to 300 c.c. capacity. He thought if care was taken to use perfectly dry air the gauges were quite reliable.

BOOKS RECEIVED.

"A Text-Book of Assaying for the Use of Those Connected with Mines." By C. and J. J. BERINGER. Revised by H. R. BERINGER. Fifteenth Edition revised. Pp. xvi.+471. London: Charles Griffin & Co., Ltd. Price 12s. 6d. net.

"Reports on the Progress of Applied Chemistry." Issued by the Society of Chemical Industry. Vol. V., 1920. Pp. 625. Price to Members, 8s. 3d.; Non-Members, 15s. London: Society of Chemical Industry, Central House, 46/47, Finsbury Square, E.C.2.

"Thermodynamics and Chemistry." By F. H. MACDOUGALL. Pp. 390. London: Chapman & Hall, Ltd. New York: John Wiley & Sons. Price 30s. net.

Monographs of Inorganic and Physical Chemistry,

"The Electronic Conception of Valance and the Constitution of Benzene." By HARRY SHIPLEY FRY. Pp. 300. London: Longmans, Green & Co. Price 16s. net.

"The Measurement of Study and Fluctuating Temperatures." By R. ROYDS. Pp. 162. London: Constable & Co. Ltd. Price 16s. net.

"Heat Transmission by Radiation, Conduction and Convection." By R. ROYDS. Pp. 238. London: Constable & Co. Ltd. Price 24s. net.

"Heat Transmission in Boilers, Condensers and Evaporators." By R. ROYDS. Pp. 302. London: Constable & Co. Ltd. Price 24s. net.

NOTES.

THE unhappy stoppage of our fuel supplies has given great impetus to the development of oil heating appliances as a substitute for solid and gaseous fuel. We are pleased to note that many useful oil heaters have been devised. The Kilson Empire Lighting Co. of Stamford, Lincs, are manufacturing heaters for linotype machines and similar purposes; judging from their drawings the burners appear to be simple and effective. It is quite possible that this information may be of use to some of our readers who may be inconvenienced by the present restrictions in other kinds of fuel.

MESSRS SIEMENS BROS. & CO. LTD., have sent us their new catalogue of primary cells and batteries. The firm has devoted much time and attention to the development of a serviceable dry cell, and having recently had an opportunity of testing these we can unhesitatingly recommend them for low resistance and durability.

AUSTRALIAN GEM TRADE WITH FRANCE.—Acting upon the advice of the French Mission which visited Australia in 1919, the New South Wales Government sent an expert to France to investigate the possibilities of trade in Australian precious stones. On his recent return to Sydney, states the *Industrial Australian and Mining Journal*, the expert expressed confidence that an important business between France and Australia will be done in the future. France, he asserted, is keen on securing the trade previously held by Germany. Agents previously bought the precious stones on Australian diamond fields and shipped them to Germany, where they were cut and polished and distributed throughout the world. France is now in a position to take Germany's place, for she has made great strides in the gem-cutting industry, and the work being turned out is decidedly superior to that executed by German gem-cutters. Australian gems, stated the expert, received a great advertisement in the Lyons Fair, his collection exciting general admiration on account of the rare quality, variety, and distinctive characteristics of the stones exhibited.—*Board of Trade Journal.*

IRON AND STEEL INSTITUTE.—The Autumn Meeting of the Iron and Steel Institute will be held, by invitation of the Comité des Forges de France, in Paris, on Monday and Tuesday, September 5 and 6, 1921. At the conclusion of the meeting in Paris, alternative visits have been arranged to works in Lorraine and in Normandy, and a party of the members have been invited to visit the Creusot Works of M.M. Schneider & Co. In order that proper arrangements may be made, it is necessary that the number likely to take part in the meeting should be ascertained before June 30.—G. C. LLOYD, Secretary, 28, Victoria Street, S.W.1

EGYPT: TENDERS INVITED FOR GENERAL STORES. —His Majesty's Commercial Agent at Cairo, Mr. E. Homan Mulock, has forwarded to the Department of Overseas Trade copies of the specification and conditions of tender relating to the supply of general stores, to the Egyptian Ports and Light-houses Administration for the second half of the financial year 1921-1922. Tenders will be received by the Director-General of Ports and Light-houses Administration, Alexandria, up to noon on June 13, 1921. The tenderer must be a person residing in Egypt or must have a representative in Egypt. In view of this condition United Kingdom firms who are not represented in Egypt may care to avail themselves of the services of a firm with an Egyptian branch through which tenders could be submitted. Names of suitable firms will be supplied on application to the Department of Overseas Trade. A copy of the specification and conditions of tender relating to this contract may be inspected by United Kingdom firms interested on application to the Enquiry Room, Department of Overseas Trade, 35, Old Queen Street, S.W.1. A limited number of copies are also available for loan to firms in the Provinces who are unable to arrange for their inspection in London. Applications for these should bear the reference number 5054/F.E./P.N.

POSTPONEMENT OF PROF. EINSTEIN'S LECTURE.— Owing to the postponement of the sailing of the *Celtic*, on which he had booked his passage from America, Prof. Einstein is unable to lecture at King's College until Monday, June 13, at 5.15 p.m. All the tickets which have been issued for June 9 will be available for that date.

DISPLACEMENT OF METALS IN SALINE SOLUTIONS. —Existing in an aqueous solution of one of its salts, in form of ions, a metal gives place to any more electro-negative-element than itself, or according to Nernst, of a sufficiently great dissolution tension with regard to the metal. Such is the case with copper displaced by zinc, and M. Barlot studied this phenomenon working with a thin homogeneous liquid layer. Thus arborisations are produced in form of a fan, "metallic spectra" in formation of which it seems that electric forces play a very important rôle.—*Comptes Rendus*, February 14, 1921.

VISIT OF THE COMMERCIAL SECRETARY TO H.M. EMBASSY AT ATHENS.—Mr. E. C. D. Rawlins, Commercial Secretary to H.M. Legation at Athens has arrived in this country on a short official visit. He will be pleased to meet manufacturers and merchants who wish to discuss with him questions relating to trade with Greece, and who may desire information or advice regarding the appointment of agents, marketing and distributing goods, terms of payment, Customs duties, or general information as to openings existing for British goods. Applications to interview Mr. Rawlins in London between May 26 and June 3 should be made immediately to the Department of Overseas Trade, 35, Old Queen Street, S.W.1., the reference number 3057 T.G. being quoted. It is intended that Mr. Rawlins shall subsequently visit a number of provincial centres.

CONGEALING POINT OF MINERAL OILS.—According to E. Lantos, mineral oils containing paraffin in solution do not comply with ordinary cryoscopic rules. In the oil industry the true point of congelation is not determined, but the solidification point, *viz.*, the temperature at which an oil, in a tube cooled with a mixture of snow and a solution of soda, and then turned with the opening downwards, does not change its meniscus during 30 seconds. In general, the slighter the viscosity, the lower the point of solidification However, in refining two Roumanian oils it was found that although viscosity decreased, the point of solidification increased, from $-20°$ C. to $-15°{\cdot}5$ C.). Galicia oils (Limanowa) containing paraffin oil had high solidification points. For example, a refined oil, rich in paraffin, with a viscosity of 2·29 had a solidification point at $+10°$ C. When the paraffin is extracted, the viscosity falls to 1·85 and solidification to $-20°$ C. These results lead to the conclusion that solutions in which the solvent and dissolved body are homologues do not comply with cryoscopic laws.—*Matières Grasses*, February 15, 1921.

PRACTICAL METHODS EMPLOYED IN THE STEARINE INDUSTRY.—The following observations are taken from a series of articles by Knor in the *Seifensie der Zeitung*. The oils and fats utilised in stearinery are kept in well-ventilated buildings with blue glass windows. They are purified by washing with sulphuric acid ($d = 1{\cdot}16$) and deodorised by blowing of compressed air after heating in a vacuum to 105° C. to eliminate water, then they are hydrolysed in an autoclave with steam at 11-12 atmospheres in presence of 3 per cent CaO, 1 to 1·5 per cent MgO, 1 per cent ZnO or 0·5per cent zinc powder, preferably a mixture of 0·5 ZnO and 0·5 Zn. Magnesia is preferable for black fats and zinc powder for fats which are not distilled. Fish-oils and vegetable fats require a greater percentage of hydrolytic agents and higher pressure. When hydrolysis is complete (after 8 to 10 hours) the steam valve is opened and the mixture let rest for two hours, for separation of the glycerin water; then the two layers are extracted from the autoclave. The soap is decomposed by running the fatty acids into boiling sulphuric acid ($d = 1{\cdot}16$). The normal density of the glycerin water attains 1·0325.—*Matières Grasses*, February 15, 1921.

BORAX AND SALTPETRE.—All fertilisers containing more than 0·5 per cent of anhydrous borax has been prohibited by the United States Minister of Agriculture. Regarding this regulation, Señor B. Diaz Ossa (*Caliche*, 1920, T.1., No. 11) describes the methods to eliminate this substance from residual nitrate of soda lyes from which nitrate of potash is recovered and directly employed in agriculture as fertiliser. He criticises the sulphurous gas process or that with bisulphite of soda as also that consisting in discharge of the liquid during crystallisation before this phenomenon is terminated. He recommends employment of calcium chloride to form an insoluble stable borate during concentration of the mother waters. After separation, complete crystallisation is operated. The proportion of $CaCl_2$ should be accurately calculated so as only to precipitate boric acid; the liquid should be neutral or slightly alkaline. The writer concludes with some remarks upon analysis of saltpetre from the point of view of American requirements.—*Chimie et Industrie*, February, 1921.

Finsbury Technical College.—The Governing Body of the Finsbury Technical College announce that the entrance examination for the session 1921-22 will be held on Tuesday, September 20 next. Applications for admission should be forwarded to the College not later than September 15, on forms to be obtained from the Registrar, Leonard Street, City Road, E.C. The programme of the College is under revision and will be issued in due course. We are pleased to learn that the work of the Chemical Department will be continued; Mr. W. J. Hale is acting head of the Department.

Mr. Henry Mayer, the Chairman of Henry Mayer & Co., Ltd., has left the Pottery and Glass Trades' Benevolent Institution the sum of £500 to be used as an endowment in perpetuity, and the income applied towards providing an annuity or annuities for the widow or widows of members. The endowment to be known as the Henry Mayer Bequest.

Principles of Analysis by Means of Reductive Flames; Research for Traces of Manganese in Presence of Iron or Other Substances.—Continuing the application of the method he gave in 1914 (Congress of the French Association for the Promotion of Science), which consists in conveying away a solid salt or oxide in a flame of hydrogen and photographing the spectra of the rays obtained by aid of an ingenious technique, M. I. Meunier applied this method to analysis of iron, thus being able to follow the elimination of manganese by the disappearance of the triplet of this metal. The method is very sensitive with pulverulent oxides or oxalates.—*Comptes Rendus*, March 14, 1921.

We have received from the Royal Insurance Co. Ltd., their eighth edition of the "Rules of Golf," as amended on September 28, 1920. It is issued in a practical and concise form, containing a comprehensive index. The Company has also issued with the above edition a small leaflet, showing the differences between the old and new Rules, and especially relating to the new standard of ball, which we are sure will be appreciated by all followers of the "Royal and Ancient Game."

Visit of the Commercial Secretary to H.M. Embassy at Madrid.—Captain U. de B. Charles, Commercial Secretary to H.M. Embassy at Madrid, has arrived in this country on a short official visit, and will be pleased to meet manufacturers and merchants who wish to consult him in regard to steps to be taken for opening up trade with Spain, and who desire information as to the state of trade in that country. Among the matters in regard to which he will be prepared to give advice and information are the appointment of agents, methods and marketing and distributing goods, terms of payment, statistics of imports, rates of Customs duties, and general information as to openings existing for British goods. Firms desirous of making appointments to interview Captain Charles in London from May 24 to June 3 should communicate immediately with the Department of Overseas Trade, 35, Old Queen St., London, S.W.1., quoting the reference 3055 T.G. If circumstances permit, it is intended to make arrangements for Captain Charles to visit other centres in the United Kingdom after June 3.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

13664—Adam, W. G.—Manufacture of amines from phenolic compounds. May 13th.
13180—District Chemical Co., Ltd.—Materials for purifying acetylene gas. May 9th.
13210—Gaillard, E. A.—Manufacture of sulphuric acid. May 10th.
13675—Hoffman-La Roche & Co., Akt. Ges., F.—Process for manufacture of 1-alley 1-3. 7-dimethylxanthine. May 13th.
13656—Oehlrich, F. J. G.—Process for production of a contact mass for catalytic synthesis of ammonia. May 13th.
13261—Wilton, N.—Manufacture of sulphate of ammonia. May 10th.

Specifications published this Week.

140051—Sasa, H.—Manufacture of phthalic anhydride.
145781—Collin Akt Ges. zur Verwertung von Brennstoffen und Mettalen, F. G.—Method of discharging ammonium sulphate from saturrater baths.

Abstract Published this Week.

Naphthylenediamine Derivatives.—Mr. G. T. Morgan of the Imperial Trust, 15, George Street, Westminster, has been granted a Patent No 160853 for improvements in the preparation of arylsulphonyl or arylenedisulphonyl derivatives of sc-naphthylenediamine or its sulphonic acids, by reducing the p-azo derivatives of arylsulphonyl-bis-sc-naphthylamines or their sulphonic acids containing the sulphonic radicle in the 2, 6, 7 or 8 position with respect to the arylenedisulphonylamino radicle. According to the provisional Specification, these bodies may also be prepared by reduction of the corresponding p-nitro compounds. The following reducing agents are mentioned as suitable: zinc dust and caustic soda, zinc dust and ammonium, chloride, iron borings and dilute acids, alkaline sodium sulphide, stannous chloride and titanous chloride. The p-azo derivatives above-mentioned are produced by condensing x-napthylamine or its sulphonic acids in the positions specified with arylsulphonic acid chlorides or arylenedisulphonic acid chlorides and causing the resulting compounds to react with diazonium compounds in alkaline media. Examples are given to the preparation of toluene-p-sulphony 1-1: 4 naphthylenediamine and its 8-sulphonic acid, benzene 1: 3-disulphonyl-bis-1: 4-naphthylenediamine and its 8-sulphonic acid, and naphthalene-2: 6-disulphonyl-bis-1: 4-naphthalenediamine.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by Jordan & Sons, Limited, Company Registration Agents, Chancery Lane, W.C.2.

W. H. S. Clark & Co., Limited.—(174721)—Registered 13th May, 1921. 56, High Street, Lewes, Sussex. To carry on the business of Manufacturers and Dealers in Manures and Fertilizers of all kinds and Dealers and Merchants of Farm and other Produce. Nominal Capital: £6,000 in 120 Shares of £50 each. Minimum Subscription: 20 Shares. Directors: W. H. S. Clark, 80, St. Helens Road, Hastings; H. J. Chapman, Ivy Bank, Sutton Park Road, Seaford; W. A. Cowley, Woodingdean, Rottingdean, Near Brighton; F. Martin, Washbourne, Sheffield Park Street, Lewes; A. Leggat, Mill Place Farm, East Grinstead; G. Hemsley, Boat House Farm, Isfield, Sussex. Qualification of Directors: 2 Shares. Remuneration of Directors: £25 each.

Devon Chemical Company, Limited.—(174769)—Registered 19th May, 1921. Harlington, Newton Abbot, Devon. To carry on the business of Chemists and Druggists. Nominal Capital: £500 in 500 Shares of £1 each. Directors: G. F. Storey, 15, Ashleigh Road, West Park, Leeds; N. V. Stow, Harlington, Newton Abbot, Devon; A. W. Simpson, H tfield, Bonnybridge; J. H. Keighley, 63, Argyle Street, Keighley; H. S. Prince, 22, Victoria Terrace, Leeds. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company.

Zeta Drug Company, Limited.—(174787)—Registered 20th May, 1921. 180, Fleet Street, E.C.4. To carry on the business of

Chemists and Druggists Nominal Capital: £500 in 500 Ordinary Shares of £1 each. Directors: T. C. King, 15, Aldersgate Street, E.C.; S. Westall, 37, Upper Berkeley Street, W.1. Qualification of Directors: £100. Remuneration of Directors: To be voted by Company in General Meeting.

MARVN & COMPANY, LIMITED.—(174800)—Registered 20th May, 1921. To carry on the business of Manufacturing, Wholesale and Retail Chemists and Druggists Nominal Capital: £500 in 500 Shares of £1 each. Directors: H.W. W. Northwood, 1, King David Lane, E.1.; (Governing Director and Chairman). Qualification of Directors: 1 Share.

Private Companies.

SLAG PHOSPHATE COMPANY, LIMITED.—(174808)—Registered 20th May, 1921. To carry on the business of Manufacturers and Dealers in Slag Phosphates. Nominal Capital: £250,000 in 250,000 Shares of £1 each. Directors: Sir J. R. Wright, Bart., Widcombe Manor, Bath; Sir W. C. Wright, K.B.E., 31, Princes Gate, W F. W. Gilbertson, Langland Bay, Swansea; J. C. Davies C.B.E., The Mount, Gowerton; G. V. Parker, Skelmorlie, Newport Qualification of Directors: 5,000 Shares. Remuneration of Directors · To be voted by Company.

MEETINGS FOR THE WEEK

Monday, June 6.

Royal Institution, 5. (General Meeting).

Tuesday, June 7.

Royal Institution, 3. "London Life" by Sir James Frazer.
Röntgen Society, 8.15.

Wednesday, June 8.

Institution of Electrical Engineers, 5.30. (Wireless Section). "Electric Oscillations along Straight Wires and Solenoids" by Prof. J. S. Townsend.

Thursday, June 9.

Royal Institution, 3. "Beethoven" by Sir Alexander C. Mackenzie
Institute of Chemistry. (At Liverpool).
Optical Society, 7.30.

Friday, June 10.

Royal Institution, 9. "Absolute Measurements of Sound" by Dr. Arthur Gordon Webster.
Physical Society, 5.

Saturday, June 11.

Royal Institution, 3. "Scott and Shakespeare" by Dr. Robert S. Rait.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

SUBSCRIPTIONS, £1 12s. per annum, payable in advance, should be addressed to the MANAGER.

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PARTNERSHIP.—Chemical Engineer and Patentee, long industrial experienc in electrochemistry and metallurgy, exc ptional research ability, desires appointment with partnership. Willing to bring, as investment, his present laboratory (well equipped for chemical electrochemical and metallurgical work) or its value. Address: Box 834, T. G. SCOTT & SON, 63, Ludgate Hill, E.C.4.

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THE GENERAL INDEX to VOLS. 1 to 100 can still be purchased at £1 (CARRIAGE EXTRA).

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4-JUL 1921

THE CHEMICAL NEWS.

VOL. CXXII., No. 3191.

THE SOIL SOLUTION IN RELATION TO THE PLANT.*

By D. R. HOAGLAND, University of California.

THE soil and plant together form a multiple phase chemical system, and a more exact knowledge of the inter-relationship of the various components of this system is requisite to the advance of scientific investigations of the soil in its relation to the plant. The fertility of any soil must be measured by its ability to produce some useful crop; thus the study of soil fertility cannot be dissociated from the study of plant growth. Perhaps these ideas may be considered too obvious to require statement, yet it is true that this point of view often fails to receive proper consideration in researches dealing with soils and plants, even when the avowed purpose is that of contributing information directly or indirectly applicable to crop production.

Innumerable analyses of soils have been made to determine the total content of plant food, or to estimate what proportion of the total quantity is soluble, under arbitrarily limited conditions, in hydrochloric acid, nitric acid, or other strong solvents, which at various times have been thought to bring into solution only the more or less available soil constituents. Notwithstanding the enormous mass of data obtained in this manner, no general and consistent correlation with crop production has ever been made. The conceptions of the soil which underlie this type of experimentation are essentially static in nature, while the plant and the soil form a dynamic system in which rates of processes are all important. In this paper the writer has for his main purpose the further elaboration of the dynamic and physical-chemical viewpoint of soils and plants, first desiring to acknowledge his indebtedness to the work of the Rothamstead Station, the Michigan Station, and others, and to the investigations of Burd and Stewart at the University of California.

Since the plant obtains its direct supply of mineral nutrients only from solution, the soil solution at once becomes the logical point of attack in investigations of plant nutrition. The difficulties met in researches in this field are manifold, and have been overcome only to a limited degree, but certain assumptions may be made with a very great measure of confidence. Whatever may be the forces by which the film water is bound to the soil particles, it must nevertheless possess many, if not all, the chemical properties of free solutions. Among these properties certain ones may become of paramount importance to the nutrition of the plant, for example, reaction, osmotic pressure, and concentration of nutrient ions. There seems to be no valid reason against the application of physical-chemical principles applying to solutions which nourish the plant.

During recent years many researches have shown that the reaction or hydrogen ion concentration of solutions is of far-reaching interest to the biologist. In the realm of soil investigations there has long existed the utmost confusion concerning the question of soil reaction. Many terms have been invented to describe a varying complex of factors, such as "sour soil," "apparent acidity," "so-called acidity," "adsorption acidity," "negative acidity," &c. Numerous investigators have been loathe to acknowledge that a soil solution could be acid in the same sense as any other acid solution. But we must of necessity recognise the fact that the soil solution is either acid, neutral, or alkaline. The investigations of the past few few years with the hydrogen electrode and special indicators seem to leave no doubt that many soils yield solutions with hydrogen ion concentrations greater than that of pure water. Such solutions are properly termed acid, and the term requires no modification.

Upon examining into the intensity of acidity (most conveniently represented by the customary *p*H values) of such solutions, we find that there is no evidence to prove that the acidity *per se* is sufficient to be injurious to most plants of agricultural interest, except in somewhat rare instances. This conclusion is upheld by experiments with solution cultures, which prove that plants may grow normally in solutions having intensities of acidity comparable with those found in most acid soils (D. R. Hoagland, 1918; *Science*, N.S., xlviii., 1-8; *Ibid.*, 1919; *Jour. Agr. Res.*, xviii., 73-117). Further confirmation is afforded by observations on certain peat soils of California. In these soils many crops, including legumes, thrive and yet the acidity is of the order of *p*H 4, 8. The so-called lime requirement of the soils is enormous, but the addition of lime has not resulted in increased crop yields.

It is, of course, undeniable that the practice of liming acid soils is most frequently beneficial to the plant, but it by no means follows that the improved environment is directly attributable to a decrease in the hydrogen ion concentration of soil solution. It has been shown that aluminum in toxic concentrations may be present in some acid soils; the decrease of acidity may be accompanied by a decreased concentration of aluminum. In other cases the base-silicate equilibrium may be of such a nature as to prevent the attainment of a concentration of calcium sufficiently great for the needs of some plants; the addition of lime may alter this system and remedy the deficiency. Many other possibilities could be suggested, including speculations concerning the effect of reaction on soil micro-organisms. Those interested only in the art of agriculture may object that it is immaterial what the mechanism may be, by which an acid soil is improved by the use of lime, but the scientfic investigator will desire to segregate out the diverse factors of the complex system and assign to each one its due weight. In no other way can the true relation between soil reaction and plant growth be ascertained.

Brief mention should be made of soils with alkaline soil solutions. Here also elementary physical chemical principles assist in the interpretation of the data. Soils containing calcium carbonate are usually referred to as alkaline soils, and it is very generally maintained that most plants, especially leguminous plants, require an alkaline medium. A more careful consideration of the chemical

*A Contribution to a General Discussion on "Physico-Chemical Problems Relating to the Soil" held by The Faraday Society, on Tuesday, May 31, 1921.

solution by the plant, the values frequently fell off to as low as 0·01° C. to 0·005° C., or even less (G. R. Stewart, *Jour. Agr. Res.*, 1918, xii., 311-68).

Analyses of water extracts of soils, periodically carried out, have contributed greatly to our knowledge of the solutes available to the plant. Studies on the relations existing between the freezing-point depression and the quantity of solutes dissolved in water extracts have indicated that in general the concentration of the soil solution is reflected in the extract. Still other applicable data have resulted from experiments on the equilibria between soil extracts and soil mass (D. R. Hoagland, *Jour. Agr. Res.*, 1920, xx., 381-95), and these have suggested that the ratios between some of the solutes may be similar in the soil solution and in certain types of water extracts.

Incomplete as our information is, we may still construct on the basis of our present knowledge an outline of some of the important characteristics of a soil solution, pertaining to its nutrient properties. It is very certain that soil solutions are of infinite diversity. The theory at one time advanced by Cameron, to the effect that all soil solutions were saturated with respect to important nutrients is of course untenable. Indeed, the fallacies of this conception were long ago clearly pointed out by Russell (E. J. Russell, *Jour. Agr. Sc.*, 1905, i., 327-46). It has required the recent work, however, to establish more definitely some of the relations existing between crop and season and the soil solution.

These relations can perhaps be conveniently

equilibria leads to the inference that the soil solution of a soil containing calcium carbonate is not necessarily always appreciably alkaline in reaction. In such a system one must take into account the partial pressure of carbon dioxide in the gaseous phase of the system. It has been well established by the work of Russell and others (E. J. Russell and Alfred Appleyard, *Jour. Agr. Sci.*, 1915, vii., 1-48) that the soil atmosphere may contain much larger percentages of carbon dioxide than the outer atmosphere. The real reaction of the soil solution will be dependent in part on the partial pressure of carbon dioxide. If this partial pressure be sufficiently great a nearly neutral or possibly slightly acid reaction will be found in such soil solutions. The hydrogen ion concentration would be subject to continuous modification with fluctuations in the carbon dioxide content of the soil atmosphere. Since the plant at certain periods may bring about a large increase of carbon dioxide in this atmosphere, it is evident that the plant may exert an appreciable effect on soil reaction in soils of this character. The soil micro-organisms have a like significance in this connection.

In arid regions soils are often found in which the reaction is determined by a sodium carbonate, bicarbonate, silicate system. Under these circumstances an excessive hydroxyl ion concentration may sometimes exist, the intensity of alkalinity being sufficiently great to destroy most useful plants. In general, for a similar divergence from the neutral point, within a limited range, the hydroxyl ion seems to be more toxic than the hydrogen ion. In these soil systems also carbon dioxide is an essential factor, and its presence tends to decrease the actual alkalinity of the solution. Recent work has indicated that it is impossible to understand the effects of such soils on plants unless this factor be given consideration.

While the reaction, or hydrogen ion concentration of the soil solution is of extreme interest in many special cases, the concentration of the nutrient ions is of universal significance to soil fertility investigations. Two great obstacles have hindered progress in this field; first, the difficulty of separating the soil solution from the soil mass, and second, the fluctuating nature of the solution. Lipman (Chas. B. Lipman, *Univ. of Calif. Pub. Agr. Sci.*, 1918, iii., 131-34) and others have attempted to obtain the soil solution with the use of great pressure, but definite conclusions have not been formulated at the present time. The approximate magnitudes of total concentration of solutes in the soil solution have been determined by Bouyoucos and McCool (G. J. Bouyoucos and M. M. McCool, *Mich. Agr. Exp. Sta. Tech. Bull.*, 24, 1916, pp. 592-631) by means of an application of the method of freezing-point depression. Some of the results secured with the aid of this procedure have thrown considerable light on the whole question, although it is not at all certain that the small differences in depressions of the freezing-point noted in some investigations do not fall within the limits of experimental error. Observations from freezing-point determination indicate that the fertile soils examined had, at optimum moisture content, solutions of concentrations represented by from 0·05° C. to 15° C. freezing-point depression, when the concentrations were at the maximum. After the depletion of the solution by the plant, the values frequently fell off to as low as 0·01° C. to 0·005° C., or even less (G. R Stewart, *Jour. Agr. Res.*, 1918, xii., 311-68).

Analyses of water extracts of soils, periodically carried out, have contributed greatly to our knowledge of the solutes available to the plant. Studies on the relations existing between the freezing-point depression and the quantity of solutes dissolved in water extracts have indicated that in general the concentration of the soil solution is reflected in the extract. Still other applicable data have resulted from experiments on the equilibria between soil extracts and soil mass (D. R. Hoagland, *Jour. Agr. Res.*, 1920, xx., 381-95), and these have suggested that the ratios between some of the solutes may be similar in the soil solution and in certain types of water extracts.

Incomplete as our information is, we may still construct on the basis of our present knowledge an outline of some of the important characteristics of a soil solution, pertaining to its nutrient properties. It is very certain that soil solutions are of infinite diversity. The theory at one time advanced by Cameron, to the effect that all soil solutions were saturated with respect to important nutrients is of course untenable. Indeed, the fallacies of this conception were long ago clearly pointed out by Russell (E. J. Russell, *Jour. Agr. Sc.*, 1905, i., 327-46). It has required the recent work, however, to establish more definitely some of the relations existing between crop and season and the soil solution.

These relations can perhaps be conveniently illustrated by a brief reference to the California experiments. Large quantites of different soils were collected in one place, and after careful mixing, they were placed in containers, each of about one ton capacity. Two containers of each soil were installed, one being cropped to barley, and one remaining uncropped. Samples of the soils were taken every two weeks, and the water extracts analysed. During the early period, while the plants were still very small, an increase was noted in the quantities of nitrate, potassium, calcium, and magnesium extracted. After the plants had begun to grow more rapidly, the amounts of these elements in the extracts started to decrease, and by the time the plants were well tillered and the heading-out stage had been reached, little, if any, nitrate remained, and in general very significant depressions of soluble potassium, calcium, and magnesium had occurred. Meanwhile the uncropped soils failed to show these decreases in the water-soluble nutrients, although marked fluctuations were found, probably associated with cycles of activity of micro-organisms. In these uncropped soils the highest point in the seasonal curve was frequently attained at the time when the cropped soils were at a minimum. The water-soluble constituents of the latter slowly increased in quantity after the periods of greatest depression but the difference between the cropped and uncropped soils persisted for a long time, sometimes being evident at the beginning of the following season. Later other crops than barley were experimented with, and very similar results were obtained.

The seasonal fluctuations which have just been described do not seem to hold for phosphate. The water-extractable phosphate on the whole is main-

tained at a fairly constant level throughout the season, but different soils yield very different quantities of soluble phosphate. While no marked changes are noted during a single season, after a number of years of cropping some soils show a decided depression in the solubility of phosphate. Thus we may assume that the crop does produce an effect on the concentration of phosphate ion in the soil solution, but the chemical system involved requires special consideration. The total quantity of phosphate extracted from a soil is approximately proportional to the amount of water used, which is not true of potassium, calcium, magnesium, and nitrate.

The next step in the investigation was to follow the absorption of nutrient elements by analysing the crop itself at various stages in the growth cycle. This task was undertaken by Burd (J. S. Burd, *J. Agr. Res.*, 1919, xviii., 51-72), and his experiments indicated very definitely that the absorption of certain elements was characterised by several distinct phases, coincident with important stages in the development of the plant. Up to the time of heading out the total quantities of all elements increased in the tops of the plants. At this period a new phase began, during which a loss of nitrogen and potassium from the tops (and possibly a slight loss of calcium and magnesium) occurred. Later there was a period of renewed absorption.

Perhaps this course of events might be thought to be inherent in the growth of the plant. When, however, plants are grown in solution cultures, and provision is made to maintain more or less continuously a sufficiently high concentration of the nutrient elements, absorption may continue throughout the cycle of growth. It would seem probable therefore, that both the diminution in concentration of the soil solution and changes in the internal metabolism of the plant are concerned in the phenomenon of loss of nutrient elements from the tops as a whole. These conclusions are based on experiments with barley, but there is reason to suppose that they are of more general application.

At this point in the discussion the question naturally arises, what are the characteristics of a soil solution producing maximum yields of crop? Many of the soils referred to in this paper produced very large yields of barley straw and grain. From this it must follow that the very low concentrations of the soil solution in the later stages of growth were not unfavourable to the production of a large crop. The important period of absorp- of nutrients for barley occurred before the heading-out stage. These conclusions may not be valid for phosphate, since, as has been stated, this ion is probably maintained at a more nearly constant concentration in the soil solution, and, moreover, absorption of phosphate continues, even during the period of loss of nitrogen and potassium. In an artificial culture solution the decrease in concentration occurring in soil solutions may be prevented. When this is done, and when the climatic conditions are suitable, a very large growth may be obtained from a single seed. Here a special and somewhat abnormal condition is produced, in which new cycles of growth succeed each other and great delay in ripening processes may be brought about. It also appears that plants grown under these conditions may acquire very high percentages of certain elements, notably nitrogen and potassium.

Having thus outlined some of the general relations of soil to plant, it may be well to consider for a moment the question of ratios between nutrient elements. Great importance has frequently been attached to the specific ratios between the salts used in preparing nutrient solutions. Certain definite proportions are claimed to be essential for optimum growth of a given plant. The writer feels that these claims are in no manner justified by the evidence adduced in their support. Very serious criticism may be made of the methods of experimentation and interpretation of data (D. R. Hoagland, *Jour. Agr. Res.*, 1919, xviii., 73-117). Another point of view bearing on this phase of nutrition may be gained by further reference to the soil experiments. It is obvious that terrestial plants have generally adapted themselves to growth in the soil, their natural habitat, and it is not unreasonable to draw certain deductions with regard to the nutrient requirements of the plant from data on soils which actually produce excellent crops. There is no evidence from observations of this character that the plant is under the necessity of obtaiing its nutrients from solutions with definite ratios between the solutes. On the contrary equal yields may be obtained from soils which give extracts with very different proportions between important elements. As is well known, the composition of plants with respect to ash constituents may vary greatly. Moreover, a brief inspection of the curves of seasonal fluctuations for soluble nutrients will show that the ratios between the solutes are constantly changing, since not all the elements are absorbed at equal rates, nor are they replenished in the soil solution in the same way. It is perhaps needless to state that extreme cases may occur, particularly in the so-called alkali soils, in which the balance of ions may become of importance.

What, then, constitutes adequacy in a soil solution? According to Burd (J. S. Burd, *Jour. Agr. Res.*, 1918, xii., 297-309), the soil extract, even of a soil of inferior production, contains at any time a sufficient quantity of water-soluble nutrients for the needs of the plant, as judged by actual absorption of these elements by crops growing in fertile soils. This apparent anomaly is capable of explanation when we take into account several important factors which limit the interpretation of data obtained by the method of water extracion. In the first place it is to be noted that at the time of greatest depletion very little nirate remains in the soil. The analytical difficulties are of such a nature that an ovestimate of the supply of nitrate may be made when only small amounts are present. Also a large quantity of nutrients not actually present in the soil solution at a given time is dissolved from the soil mass by the excess water used in making the extracts. As already pointed out by Russell, (E. J. Russell, *Jour. Agr. Sci.*, 1905, i., 327-46), diffusion is a very important matter in this connection. Availability of nutrients should properly be measured by the rate at which these are supplied to the absorbing membranes of the root system, but experiments based on water extracts cannot determine availability in this sense with any degree of accuracy. Without doubt the colloidal nature of the soil and the type of plant must be taken into consideration.

For these and other reasons it may not be possible to correlate the analyses of water extracts of soils with differences in productivity, except when the magnitudes are fairly large, but one is perhaps justified in believing that the seasonal curves for aqueous extracts of soils from the most secure basis so far considered for interpreting the nutrient properties of the soil in terms of plant production. Information leading to a greater appreciation of the role of the soil solution must also be fundamental to any rational explanation of the effects of fertilisers on soils and plants.

Our thesis concerning the plant and soil as a chemical system brings us to the consideration of another phase of the whole question. The growth of the plant is dependent not only on the soil, but on temperature, light, and humidity—the climatic complex. It has sometimes been said that weather has more to do with crop yield than any modification which can be made in most soils. Furthermore, the climatic complex influences the soil solution directly and indirectly. The requirements of the plant probably vary with its aerial environment, and the effect of the plant on the soil solution must likewise vary. Neither can the effects of climatic conditions on the activities of micro-organisms be neglected, since biochemical processes are of paramount importance in their influence on the soil solution.

The dynamic view-point of soils and plants leads to certain very clear suggestions for future experimentation on soils. The rates of solubility carbon dioxide production, nitrification, absorption of solutes by different plants, &c., must receive much more attention, and plants must be grown under definitely controlled environments. This means that in certain experiments light, temperature, and humidity should be subject to variation at will. The difficulties of an adequate control in soil and plant experiments are immense, but the field of research which would be opened by these refinements of experimental methods is unlimited in its opportunities. By such researches we may hope to understand to a far greater degree than heretofore the complex system of chemical reactions which determine every step in plant growth.

THE ESTIMATION OF HYPOCHLORITES AND CHLORATES BY HYDRAZINE.

By ALEXANDER KILLEN MACBETH.

De Coninck (*Compt. Rend.*, 1898, cxxvi., 1042) pointed out that hypochlorites, amongst other agents, were capable of oxidising hydrazine with the liberation of nitrogen; but although the observation was published over twenty years ago, no attempts appear to have been made to apply the gasometric method suggested by the reaction to the estimation of hypochlorites in solution. Williams (*Proc. Chem. Soc.*, 1912, xxviii., 327) employed hydrazine for such estimations, but his method was a volumetric one, the end point in the titration being determined by starch iodide paper. His values for hypochlorite present in solution, obtained by this method, agreed with the results calculated from titrations with arsenious acid, and the reaction was accordingly represented according to the equation

$$2MOCl+NH_2.NH_2=2MCl+N_2+2H_2O.$$

The gasometric method depending on the nitrogen liberated is found to give good results, and furnishes a rapid and convenient means of estimating hypochlorites. The operations are accurately and quickly carried out if a Van Slyke nitrometer (*J. Biol. Chem.*, 1912, xii., 278) is employed. Solutions of potassium hypochlorite were prepared by passing a slow stream of chlorine into a cooled aqueous solution of caustic potash, an excess of chlorine being avoided. 5 cc. of this solution were introduced into the deaminising bulb, and 7 cc. of an alkaline solution of hydrazine added. The latter is conveniently prepared by dissolving 5-10 grms. of hydrazine sulphate and 10-15 grms. of caustic potash in 100 cc. of water. Nitrogen is rapidly evolved, and after the temperature has become steady the volume of nitrogen liberated is noted. Comparison of the values obtained by this method with those determined by titrations with arsenious acid or sodium thiosulphate and iodine show that the nitrogen is evolved quantitatively according to the equation given above. For example, in one set of experiments the hydrazine estimation gave a result of 16·13 grms. of potassium hypochlorite per litre, the arsenic titration gave a figure 16·063 grms., and the thiosulphate method gave 16·11 grms. In another series the values were 23·55, 23·54, and 23·55. With more concentrated solutions a similar agreement was noted. Each cc. of nitrogen, measured at N.T.P., therefore corresponds to 0·008079 grms. KClO or 0·004687 grms. HClO.

Very good results were also obtained in estimating the available chlorine present in bleaching powder. The reaction proceeds rapidly according to the equation

$$Ca(OCl)_2+NH_2.NH_2=CaCl_2+N_2+H_2O.$$

Each cc. of nitrogen, measured at N.T.P., therefore corresponds to 0·006328 grms. of "available" chlorine. Thus, a solution of bleaching powder which required 13·0 cc. of N/10 arsenious acid for the titration of 10 cc., was found on treatment with hydrazine to liberate 15·6 cc. of nitrogen at 18°, 760 mm. from 20 cc. of solution. The former value gives 4·6 grms. of "available" chlorine per litre; the latter gives 4·63 grms. Values obtained in another series of experiments were respectively 21·9 grms. and 21·88 grms. per litre.

It is thus evident that the method is a rapid and accurate one for the estimation of hypochlorites in the absence of free chlorine. Good results are not obtained if this is present.

Hodgkinson (*J. Soc. Chem. Ind.*, 1914, xxxiii., 815) pointed out that alkali, and other, chlorates were acted upon by hydrazine salts in the presence of fragments of copper wire, copper oxide, iron and iron salts, and other catalysts. The chlorates are completely reduced, and the reaction proceeds according to the equation

$$2KClO_3+3NH_2.NH_2,HNO_3= 6H_2O+3N_2+3HNO_3+2KCl.$$

In his estimations, Hodgkinson used an excess of the hydrazine salts, and after the reduction was complete, the excess of hydrazine was destroyed by treatment with potassium permanganate and nitric acid; the chloride in solution was then determined in the usual way, and the original amount of chlorate was thus calculated. It seemed probable that the gasometric method might be conveniently applied in the estimation of chlorates, but the results we obtained were highly unsatisfactory in all cases.

THE PURIFICATION AND SOME PHYSICAL PROPERTIES OF CERTAIN ALIPHATIC ALCOHOLS.

By ROGER F. BRUNEL, J. L. CRENSHAW and ELISE TOBIN.

(Continued from 258.)

The Boiling-Point Apparatus.—The apparatus finally adopted is shown in the original paper. It is 32 mm. wide in the main part, and 53 cm. high. The air jacket is preferable to an asbestos wrapping since the behaviour of the boiling liquid can be watched. The glass stopper is drawn down to a neck of 11 mm. diameter so that a small cork serves to hold the thermoelement. The same cork was used continuously so that any soluble material must soon have been extracted, and any absorbed alcohol could easily be driven out. Gold scraps were usually placed in the apparatus to facilitate boiling, but experiments without them seem to have proved them superfluous. With this apparatus about 20 cc. of alcohol sufficed for a test.

The side arm was made of tubing of 10 mm. internal diameter in order to avoid rise above atmospheric pressure with vigorous boiling. With a sufficiently narrow outlet tube such changes may occur, but this is a source of error easily avoided. The most persistent difficulty which we had to overcome was the *fall in boiling point* which always occurred with the higher boiling alcohols *when the flame was raised* and the violence of boiling increased. It was suspected that the back-flow from the condenser was the cause of this, and the apparatus with the return tube for condensed liquid was therefore adopted. But this was not the cause of the trouble. The real cause was found to lie in the failure to dry the alcohol thoroughly. (The boiling-point of a perfectly pure substance can, as a matter of fact, be determined with very few precautions as regards the apparatus. We finally tested the boiling point of *n*-butyl alcohol in an apparatus consisting of a tube 33 mm. in diameter by 45 cm. high, with a side tube for condenser near the top, with no air jacket or insulation of any sort, but with shield about the thermoelement. The result was identical with that obtained with the other apparatus. It would appear that such an apparatus as that of Edwards (*C.A.*, 1918, xii., 1261), in which care is taken to have the inner chamber surrounded by a jacket of vapour at the same temperature, involved somewhat unnecessary precautions. Nevertheless, a jacket of some sort is, of course, desirable, since, otherwise, air currents interfere with careful regulation of the rate of boiling).

Drying Agents.—The alcohols were all originally boiled with and distilled from lime until no apparent further action occurred before fractionation was begun. The subsequent prolonged boiling during during the fractionation appeared to dry them completely. When, however, the boiling points were tested, it was found necessary to repeat the drying. (See Young and Fortey, *J. Chem. Soc.*, 1903, lxxxiii., 65, in this connection. The remarks of Winkler, *Ber.*, 1905, xxxviii., 3616, regarding over emphasis which he considers has been placed on the hygroscopicity of ethyl alcohol, appear to us misleading. We find it impossible to keep our compounds dry). We at first tried to distil the small quantities needed for the tests (about 20 cc.) from a drying agent into the well-dried boiling-point apparatus, but found it impossible to get a constant boiling specimen in this way. The tests have therefore been made with the drying agent in the apparatus. A test of the boiling point in this apparatus apparently shows the presence of the least trace of moisture, at least when the alcohol boils above 100°. With a sufficiently low flame the water, in such a case, gradually accumulates in liquid condensed in the upper part of the apparatus and in the condenser, beyond the point where it can be washed down. The boiling point gradually rises to a maximum, which has proved to be very close to the true boiling point of the alcohol, provided the amount of water present is not too great. *But as soon as the rate of boiling is increased so that the walls are washed down, the temperature drops.* Such fluctuations have often amounted to 0·3°, and were always observed with alcohols boiling abve 100°.

This explanation of these fluctuations is borne out by the fact that with sufficient drying the boiling point became constant. Furthermore, in the case of several specimens of alcohols which were not boiling constantly, the apparatus was tipped and the alcohol distilled through the side arm. The first few drops of such distillates in every case turned copper sulphate blue, while water was not detected in the main portion of the distillate by the same test.

The complete drying of these specimens, presumably nearly dry at the start, was, however, so difficult that the action of drying agents was given special consideration. The matter does not appear to have been thoroughly discussed in the literature. When a metal or metallic oxide is used to dry an alcohol, the following set of equilibria must exist as soon as hydroxide is formed :

$$\begin{array}{ccc} \mathrm{MOR+HOH} & \rightleftarrows & \mathrm{MOH+HOR} \\ \downarrow\uparrow & & \downarrow\uparrow \\ \mathrm{MOR} & & \mathrm{MOH} \\ \text{solid} & & \text{solid} \end{array}$$

M being the metal, and R the alcohol radical.

The effectiveness of the drying agent will evidently depend upon (1) the equilibrium constant of the reaction in solution, which, however, should not vary greatly with different metals; (2) the solubility of MOH and MOR. The solubility of the base should obviously be as small as possible, while solubility of the alcoholate will be favourable.

In addition, the dissociation pressure of water over the hydroxide must be taken into account, although this is probably too small with any of the metals concerned to be of any consequence (see Johnston, *Jour. Amer. Chem. Soc.*, 1908, xxx., 1357).

The velocity with which a drying agent will act is a different matter. It obviously depends upon the rate of its reaction with water, but when the concentration of water becomes low so that the velocity of its reaction with the drying agent is very small, a rapid action of the drying agent

with the alcohol, forming an alcoholate which is appreciably soluble, will be as effective as direct action with the water, since the alcoholate will at once react with the water, precipitating metallic hydroxide.

Sodium, in view of the above considerations, could not be expected to be an effective drying agent, by reason of the high solubility of the hydroxide. The addition of sodium to a specimen of *n*-butyl alcohol in the boiling point apparatus proved to be quite without effect. The fluctuation of the boiling point was the same after its addition as before, while the maximum temperature attained with a low flame was 0·015° below the true boiling point.

Lime should be much more effective. Lassar-Cohn (Lassar-Cohn, "Arbeitsmethoden," 1906, i., 265), quotes Smith (Smith, *Arch Pharm.*, 1876, p. 356) as having shown that 50 cc. of alcohol in contact with lime contains only 0·0005 g. of solid. Since the hydroxide is probably less soluble than the alcoholate, the equilibrium must be driven far to the right, so that the alcohol is practically dry.

The amount of water which could remain in such a solution, in the presence of lime is, moreover, limited to the amount which would have a vapour pressure equal to the dissociation pressure of water over calcium hydroxide at the temperature concerned. At the boiling point of butyl alcohol, with which we have tested this question, 117°, this pressure would be, according to Johnston's (*loc. cit.*) equation, 0·00002 mm. It would appear that such alcohol could reasonably be called dry.

Mendelejeff (*Z. Chem.*, 1865, p. 261) nevertheless claimed that alcohol could take water from calcium hydroxide, and when difficulty was met with in drying the alcohols completely with lime the matter was tested by addition of calcium hydroxide to thoroughly dried butyl alcohol. In the two most conclusive experiments *n*-butyl alcohol was first dried with aluminum amalgam until it boiled constantly at 117·705° and 117·707° respectively. The first specimen slightly hydrated lime, to the second freshly slaked lime dried by brief heating to 200° was added. In neither case was the boiling point altered by 1 μv., even after further standing and boiling.

Calcium acts more rapidly than lime, largely because of the rapid formation of the alcoholate. In the only case in which we used it, however, a constant boiling point was not obtained, and since both Osborne, McKelvy, and Bearce (*Jour. Wash. Acad. Sci.*, 1912, ii., 95), and Robertson and Acree (*Amer. Chem. J.*, 1913, xlix., 494) found that ethyl alcohol had a higher density when dried with calcium than when dried with lime, it appears possible that the calcium usually contains some impurity which renders it unsuitable for use. (The trouble may be caused by ammonia. Winkler (*Z. angew. Chem.*, 1916, xxix., i., 18) describes a method of removing this. According to Delépine, (*Jahrb. Chem.*, 1892, p. 196, ammonia raises the density of alcohol).

Barium oxide appears to act more rapidly than lime, presumably, again, because it forms alcoholate more readily, at least with some alcohols. We have not found that it dries the alcohols more thoroughly than lime, which is not surprising, since any further reduction in the amount of water below what can eventually be reached lime, probably could not be detected.

Aluminum amalgam, recommended by Wislicenus and Kaufmann (Wislicenus, *Ber.*, 1895, xxviii., 1323; Kaufmann, *J. prakt. Chem.*, 1896, [2] liv., 54), we have found to be very effective. It dries butyl alcohol, with which it forms alcoholate readily, much more rapidly than *iso*-propyl alcohol, with which the alcoholate formation is slow. In view of the fact that aluminum hydroxide dissociates partially at 200°, it would appear that the dissociation pressure of water might be sufficient at 117° to prevent thorough drying of the alcohol. There is, perhaps, not conclusive evidence that aluminum oxide rather than hydroxide is not formed, or possibly a partially hydrated oxide. Some of our best tests were made with this drying agent, and although we did not discover that lime or baryta did not eventually produce the same result, the aluminum hydroxide it nevertheless the most satisfactory reagent we found, on account of rapidity of its action.

Densities.—The densities have been determined with a pycnometer of the Sprengel type, with arms bent up and thermometer fused in, with a capacity of 8·2760 cc. at 25°. The thermostat is controlled to ±0·02° or better. To protect the liquid in the pycnometer from a fine, hardly visible spray thrown up by the vigorous stirring of the thermostat, small glass tubes, closed at the outer end, were fitted loosely over the arms. Without these it appeared that the density altered slightly when the pycnometer remained long in the thermostat. The density determinations are accurate to ±0·00002.

Refractivities.—The refractivities were determined with a Zeiss-Pulfrich refractometer. Accuracy to the fourth decimal in absolute value of the refractive index is barely obtainable with our instrument, although occasionally a 5 in the fifth decimal is thought justifiable. Constant temperature was secured by a slow current of water run through a copper coil in the thermostat.

As regards the relative value of the various physical properties as a criterion for the purity or identity of such substances, it is to be noted that we have had no difficulty in preparing specimens agreeing in boiling point to 0·01°. The agreement in refractivity to the fourth decimal has also frequently been satisfactory. Nevertheless, the determination of the density to the fifth decimal has in some cases shown such specimens not to be identical. If these are assumed to be, respectively, the degrees of accuracy easily attainable in the determination of these constants, it is evident that the densities are the best test of the purity of the substances.

Preparation of alcohols.—Ethyl, *n*-propyl, *n*-butyl, and *iso*-butyl alcohols were the best commercial products obtainable.

The secondary alcohols here described, as well as others not yet fractionated, were prepared by catalytic reduction of ketones under pressure, with nickel oxide as catalyst. The method is, in principle, that of Ipatiew (*C.A.*, 1907, i., 2878, and other articles in the *J. Russ. Phys. Chem. Soc.*), although the apparatus was designed by Bergius

(somewhat like that described by Bergius, *Dissertation*, Halle, 1913).

The bomb is a steel tube, 60 cm. long, and 30 mm. inner diameter, with 1 cm. walls, rotated in a horizontal position in an electric furnace. The capacity is 260 cc., and it is usually half-filled with ketone. The reduction goes on rapidly at any pressure above about 45 kg., at temperatures of 150-200°, but in order to accelerate the reaction, as well as from the necessity of introducing the requisite quantity of hydrogen, an intial pressure of 1363 kg. is usually used. This quantity of hydrogen will react completely in less than 10 minutes.

This method has several advantages over that of Sabatier and Senderens and their collaborators, once the apparatus is installed. The catalyst may be prepared with much less care, nickel nitrate being heated to redness; the oxide need not be reduced to metallic nickel; commercial electrolytic hydrogen is pure enough, and oxygen need not be excluded with particular care; by taking care that there is an excess of hydrogen (usually about 230 kg.) during the final heating, the reaction, which is reversible, can be driven practically to completion and 130 cc. of almost pure alcohol can be prepared per day.

Experimental part.

All of the boiling points recorded have been reudced to 760 mm. to facilitate comparison. Since the values recorded in the literature for dT/dp are not in agreement, even for ethyl alcohol, we have used values deduced from the boiling points of our own specimens on different days. The disagreement in the values found for dT/dp is doubtless due to the fact that this property is very susceptible to the influence of impurities if their boiling point differs greatly from that of the alcohol.

The boiling points in the determinations with the thermoelement were in some cases constant to 1 μv. (0·002°), or less. Where they were not constant, the temperature given is the maximum and the magnitude of the fluctuation is indicated. The values obtained by the authors at the Bureau of Standards are also given. The differences between these values and those eventually obtained are doubtless due to the moisture of the specimens. These values are, however, near enough to those obtained with the thermoelement to show that there is no error of great magnitude in either set of values.

Where distillation with the thermoelement is mentioned, the data refer to the distillation of small specimens from the boiling-point apparatus.

Complete data are given for the final distillation of many of the specimens. In particular, they are given where the constant boiling portion of the distillate was divided into several fractions. The temperature ranges for the fractions are based on the thermometer readings, but the actual temperatures are all corrected in accordance with the best value obtained for the boiling points.

Ethyl alcohol.—Boiling point: (1) thermoelement: aluminum amalgam, 78·317° (77·979° at 750·35 mm.); (2) thermometers: 78·31°, 78·32°, 78·33°; mean,: 78·32°; (3) obtained by the authors at the Bureau of Standards, 78·42°. The best specimens distilled entirely at constant temperature, except for less than a grm. at the beginning.

n-Propyl alcohol.—Boiling point: (1) thermoelement: aluminum amalgam, 97·19° (0·01°); (2) thermometers: 97·19°, 97·19°, 97·17°; (3) obtained by the authors at the Bureau of Standards, 97·12°.

In view of the particularly numerous and discordant values for the physical properties of propyl alcohol recorded in the literature, the following data for the distillation of our best specimen are given.

A. Weight before distillation, 216 g. I. 97·04—97·17°; 5 g. II. 97·17-97·19°; 27 g. III. 97·19°; 114 g.

The temperature remained constant until the distillation stopped, but the amount of alcohol left in the still was much larger than usual. Data for our other specimen are given in Table I. below.

Iso-propyl alcohol.—Boiling point: (1) thermoelement: boiled 4 hours with lime and distilled, 82·239-82·263°; boiled 6 hours with lime and distilled; 82·257-82·267°; boiled 4 hours with aluminum amalgam, 82·259° (0·004°); (2) thermometers, 82·27°, 82·28°, 82·29°; mean: 82·28°; (3) obtained by the authors at the Bureau of Standards, 82·25°.

This alcohol was distilled in glass columns for fear of re-oxidation by contact with the brass, but this was later found to be a needless precaution. The data for the best specimen (A) are as follows: wt., 210 g. I., 82·12-81·25°; 8 g. II., 82·25-82·26°; 14 g. III., 82·26°; 147 g. IV., 82·26°; 30g.

The data for physical properties of other specimens are given below.

n-Butyl alcohol.—Gentle boiling with the drying agent does not dry the alcohols boiling above 100°, since the water distils out of the liquid and remains in the condensate in the upper part of the apparatus. It is necessary occasionally to boil the alcohol up vigorously and wash the apparatus down.

Boiling point: (1) thermoelement: boiled with barium oxide, 117·706° (0·003°); same 117·707°, maximum, not constant; metallic calcium, 117·712° (fluctuations, 0·01°) (this was not a very reliable determination, and does not indicate inferiority of the calcium as a drying agent). Aluminum amalgam, 117·705° (0·003°); same, 117·707° constant; (2) obtained by the authors at the Bureau of Standards, 117·686°.

For the alcohols above 110°, the values obtained with the thermometers during the distillation are in such disagreement as to be of no value. In this case they disagreed by over 0·1°.

Data for distillation of two specimens from different sources follow: (A) I., 117·69-117·70°, 19g.; II., 117·70-117·71°, 16 g.; III., 117·71°; 303 g. (B) wt., 610 g. I., 117·54-117·64°, 9 g.; II., 117·64-117·67°, 36 g.; III., 117·67-117·70°, 45 g.; IV., 117·70-117·71°, 28 g.; V., 117·71°, 251 g.; VI., 117·71°, 103 g.; VII., 117·71°, 65 g. V., VI., VII., total, 419 g.

The low boiling fractions in B are larger than they should have been owing to poor control of the rate, which reached 100 drops a minute at times. To secure small low boiling fractions it is advantageous to conduct that part of the distillation very slowly. The constant boiling portion in B was again divided.

(To be continued).

PRESENTATION TO DR. FREDERICK BELDING POWER

(Late Director, Wellcome Chemical Research Laboratories London).

THE presentation of a medal, conferred by Mr. Henry S. Wellcome, took place in the Assembly Hall of Cosmos Club, Washington, U.S.A., on May 9, 1921.

Dr. DAVID FAIRCHILD opened the meeting by reading letters from the following gentlemen, expressing regret for their inability to attend the presentation : Dr. Thomas B. Osborne, of New Haven; Conn., Prof. Marston T. Bogert, of Columbia University, New York City, Prof. Chas. Baskerville, of the College of the City of New York, Prof. W. A. Noyes, of the University of Illinois, Prof. Rodney H. True, of the University of Pennsylvania. After reading the letters he stated that the meeting was open.

Dr. CHARLES D. WALCOTT, Secretary of the Smithsonian Institution, and President of the National Academy of Sciences, then read the following presentation address :

"Ladies and Gentlemen—We have gathered here this afternoon to do honour to Dr. Frederick Belding Power, who, for 50 years, has spent his thinking hours among the complicated molecules of organic compounds; who, because he possesses that peculiar faculty of exhausting each subject which he takes up, has had the greatest influence both in America and Great Britain in raising the standard of our pharmacopœias; who has gained distinction by his most difficult and life-consuming researches into the chemical composition of plant compounds.

As a lasting tribute to these 50 years of research and in commemoration of those which he spent as Director of the Wellcome Chemical Research Laboratories of London, I have been asked by Mr. Henry S. Wellcome, their founder, to present him with this gold medal, which bears the following inscription : "To Frederick B. Power, PhD., LL.D., in recognition of his distinguished services to science during 18½ years as Director of the Wellcome Chemical Research Laboratories, London. Presented by the founder, Henry S. Wellcome, 1914."

Dr. Power graduated from the Philadelphia College of Pharmacy in 1874, in the same class with his life-long friend, Mr. Wellcome, who urged him to pursue his studies in Germany. He spent the years from 1876 to 1880 in Strassburg, becoming the assistant to Flueckiger, one of the greatest pharmacologists of Europe. Returning to America, he spent nine years in the organising and building up of the Department and School of Pharmacy in the University of Wisconsin, four years in researches on essential oils in a newly-organised chemical works near New York, and in 1896 Mr. Wellcome appointed him Director of his chemical research laboratories in London. For 18½ years he devoted his time exclusively to chemical research, and the direction of a staff of research workers under him. 170 important scientific memoirs were published from the laboratories during this period. These covered a wide field of investigation, for which material was obtained from all parts of the world. Among these a very notable and complete study was made of the East Indian chaulmoogra oil, which resulted in the discovery of some physiologically active acids of an entirely new type. These form the basis of the new treatment of leprosy which gives promise of effecting a complete cure of one of the most terrible diseases of mankind.

During these years in London, Doctor Power had the opportunity of meeting and forming the close friendship of the foremost scientific men of Great Britain. The recogniton of his work by the leading chemists and other scientists of Europe would be perhaps exemplified in the high tribute paid to him by the late Lord Moulton, one of the most learned and versatile men in Europe, who was entrusted by Kitchener with the task of producing the high explosives for the war. Shortly before his death, he chided Mr. Wellcome for permitting Dr. Power (who for family reasons had returned to America) to leave Great Britain, for, as he remarked, "there was no one in Europe who could fill his place."

In 1908, the University of Wisconsin, commemorating the 25th anniversary of the formation of its Department of Pharmacy, conferred upon Dr. Power, its founder, the degree of LL.D., and in 1913 the Chemical, Linnean and Pharmaceutical Societies of London awarded him the Hanbury Gold Medal, a distinction only once previously bestowed upon an American. This was followed by the presentation of an illuminated address and an album containing the signatures of contributors from many parts of the world.

Dr. Power, in recognition of your distinguished services to science and in commemoration of the years which you spent as Director of a laboratory devoted to chemical research, I have the honour to present to you this gold medal of appreciation from your life-long friend, Mr. Henry S. Wellcome, who, although with us this afternoon, is unfortunately prevented by a severe throat affection from addressing us himself. In presenting it he wishes to explain that war conditions have prevented its earlier execution and presentation."

Dr. POWER acknowledged the medal as follows : "Dr. Walcott, I feel it to be a great honour to receive at your hands the beautiful medal which my friend, Mr. Wellcome, has so kindly and generously bestowed upon me, and I deeply appreciate the sentiments which you have so eloquently expressed concerning my work. I can assure you, Dr. Walcott and Mr. Wellcome, that this memento will always be regarded by me as one of my most precious possessions. It is difficult and well-nigh impossible on an occasion such as this to express adequately in spoken words the thoughts that are uppermost in my mind, for there are many happy recollections when a friendship formed in boyhood has continued uninterruptedly during a period of nearly half a century. I cannot but be reminded that it is just 25 years ago this month when I left America for London to undertake the organisation of the Chemical Research Laboratories which Mr. Wellcome desired to establish, and that the first public announcement of his purpose was made on the evening of July 21, 1896, in a beautiful salon of the great metropolis, where, by the invitation of Mr. Wellcome, a number of the most distinguished scientific men of England were asesmbled, whom it was my privilege to meet. One of the guests on that occasion was the late lamented Lord Moulton, whose brilliant legal

career and service to science, especially during the strenuous years of the war, have won for him an enduring fame. The work that was so auspiciously inaugurated on that July evening it was my privilege to conduct for a period of 18½ years, and, although years of hard and earnest toil, they were replete with happy associations, and I trust, not without some benefit to the science that it was my endeavour to serve.

There is one dominating thought that I should like particularly to convey to my friend Mr. Wellcome, and that is embodied in an expression of gratitude. I am grateful for the encouragement and inspiration received from him on our journey through life, for we have travelled long and far together, but above and beyond all, I am grateful for having possessed through so many years so kind, generous, and true a friend. For this latest expression of your kindness, Mr. Wellcome, I beg you to accept my warmest thanks, and I desire also to extend my hearty thanks to Dr. Walcott for having so happily conveyed to me your beautiful gift."

Dr. WALCOTT then adjourned the formal meeting after inviting all those present to meet Dr. Power, and to add a word of personal appreciation to those given formally. A social hour followed, with light refreshments.

PROCEEDINGS OF SOCIETIES.

SOCIETY OF GLASS TECHNOLOGY.

THE May Meeting of the Society of Glass Technology was held in the Applied Science Department, the University, St. George's Square, Sheffield, on Wednesday, May 18, 1921, at 2.30 p.m., the President, Dr. MORRIS TRAVERS, F.R.S., in the Chair.

The first paper was entitled "*The Shrinkage, Porosity, and Density of British Fireclays after Firing at* 1500° *C.*" By EDITH N. FIRTH, B.Sc. and W. E. S. TURNER, D.Sc. The paper was illustrated by lantern slides and by specimens.

Prof. Turner, who gave the paper, said :"The paper and the data which are to be presented represent a continuation of the work which has been done, and details of which were supplied a year ago here at Sheffield, on certain physical properties of British clays taken from different sources throughout England, and one or two sources in Scotland. The first paper gave an account of certain general characteristics, and the amount of shrinkage which was observed when samples of these clays were heated at various temperatures up to 1400° C. In addition to the shrinkage, the porosity of the different samples was determined, and two other properties, perhaps of less importance, namely, the density, both actually of the clay itself, and the apparent density of the fired pieces. Another point in connection with the tests mentioned at the time was that the firing was not carried out by heating the clay slabs up in company with a seger cone and then taking out the slabs as soon as the certain cone had begun to squat, but the slabs were heated up in an electrically-fired furnace until the shrinkage remained constant. It was the desire of the workers, and certainly necessary for information's sake, especially in the somewhat hotter furnaces used in the glass industry, that the measuring should be carried to a still higher stage, in fact, at as high a temperature as possible. Attaining a higher temperature, especially beyond 1400° C., is by no means easy, but at any rate, measurements have been carried out at 1500° C. We hope that a still further stage may be reached at some time. Results presented deal with the same set of clays as previously, 27 of them in number, and they have had their shrinkages and their porosities, as well as the actual density and the apparent density determined between 1400° and 1500° C. Some further change occurs with all the samples. Consider first of all the shrinkage. In eight cases there is not a further contraction, but an actual expansion; the shrinkage is negative. In the case of the porosity there are two only which show a distinct increase in porosity between 1400° and 1500° C., all the remainder showing either small or in some cases quite a large diminution of porosity.

In regard to the actual extent of the shrinkage where further shrinkage was found, it was considerable in the case of the Ayrshire bauxitic clay, Wortley clay, one of the Yorkshire clays, and also one of the Stourbridge clays In regard to the porosity, the two clays which give an increased porosity are both of them Yorkshire clays.

Now increased porosity is a change which is not to be desired because it will usually be a sign of the phenomenon of blistering, which takes place when clays are heated above a certain temperature; that is to say, are "over-fired." What takes place precisely at this point we have no very precise information, other than this, that the material gets spongy, not only the surface, but the interior mass begins to swell, and loses its value as a refractory material. There are some seven clays which show blistering, and therefore are not usable outside the range between 1400° and 1500° C. Those clays are Kilmarnock, Wortley, a German clay (Grossalmerode), two Halifax clays, and two Stourbridge clays, the worst being Halifax clays. In five out of the seven clays the blistering is only at the surface. There is a general swelling developed in two of them. These are the two Halifax clays. That means that they are not capable of being used beyond the 1400° limit.

It has been shown in the first place that 25 out of 27 of the samples of British clays, excluding for the moment Grossalmerode, are capable of being used between 1400° and 1500°. This does not mean to say that they should all be used. Of these 25, six undergo expansion between 1400° and 1500° C.; in other words, their behaviour becomes somewhat irregular, perhaps somewhat anomalous, and on that ground one would perhaps avoid using them.

Besides the results stated, the actual structure of the burnt pieces needs to be examined. Some of these samples have been sent on to Mr. G. V. Wilson, who has previously done valuable work for the industry, and we hope he will examine them. Our President, Dr. Travers, was also making some valuable suggestions during the lunch hour about the possibility of X-ray examination, and I hope it may be possible for this examination, as he suggests, to be carried out."

The second paper was entitled *"The Effect of the Rays from Radium, X-rays, and Ultra-violet Rays on Glass."* By J. R. Clarke, M.Sc., F.Inst.P.

The results obtained by previous workers are summarised, and then experiments, which were carried out in order to ascertain the effect of particular oxides, and to see whether the concentration of the oxide had any influence on the colour, are described. Seven lime-soda glasses, three of which contained selenium, and three cobalt, were exposed to the action of the $\alpha+\beta+\gamma$-rays, $\beta+\gamma$-rays, γ-rays, X-rays, and ultraviolet rays. The first six were coloured brown by the β-rays, and the depth of coloration corresponding to the range of the β-particles in the glasses, and the intensity of the coloration being greatest on the surface and decreasing towards the interior; it increased with increased selenium and cobalt content. As the radiation was prolonged, the intensity increased to a maximum, which depended on the percentage of colouring agent, and then remained constant; the intensity in the interior tended towards the same maximum as that on the surface. The seventh, pure lime-soda glass, was only affected by the α-rays, being faintly coloured on the surface only. None of the glasses were coloured by γ-rays, X-rays, or ultraviolet rays with the exposures given.

All the glasses fluoresced when kept in radium emanation, but a "fatigue" effect was observed at about the same time as the maximum intensity of coloration was reached. It is thought that the α-rays are the chief agents in producing fluorescence, though the β-rays are also effective. None of the glasses fluoresced under the action of X-rays, but the pure lime-soda glass and the selenium glass fluoresced slightly when exposed to ultraviolet rays. All the glasses exposed to radium emanation exhibited thermoluminescence with disappearance of colour at temperatures of 100°, 160°, and 235°.

The colouring of the glasses is concluded to be due to the formation of colloidal particles in the glasses. It is suggested that the presence of such particles may be explained by the action of the α- or β-rays on dissociated ions already present in the glasses. The fluorescence is held to be due to mechanical bombardment of the glass molecules by the rays.

SOCIETY OF PUBLIC ANALYSTS.

Ordinary Meeting June 1, 1921.

Mr. Alfred Smetham, President, in the Chair.

A Certificate was read for the second time in favour of Mr. W. N. Stokes, B.Sc., A.I.C.

The following were elected Members of the Society: Messrs. Thomas Henry Pope, B.Sc., F.I.C., William Ellard Woolcott.

The following papers were read:

"The Composition of Egg Powder." By F. F. Beach, T. E. Needs, and Edward Russell, B.Sc., F.I.C.

The authors record the results of the examination of the so-called egg powders, comparing them with ordinary baking powders. A table of compositions is appended and it is suggested that a standard based on certain specified figures might be laid down for a minimum percentage of actual egg in such preparations.

"The Colorimetric Method of Determining Hydrogen-Ion Concentration: Some Uses in the Analytical Laboratory." By Norman Evers, B.Sc., F.I.C.

The colorimetric method of determining hydrogen-ion concentration by means of indicators is described. Examples are given of its usefulness in replacing titration methods in the determination of the "acidity" or "alkalinity" of various products, and of the purity of certain fine chemicals.

"The Estimation of Woody Fibre in Cattle Foods." By F. Robertson Dodd, F.I.C.

The author, referring to the discrepancies between the results of different analysts working on the same sample by varying processes, suggests a modification of the method which would tend to obviate this.

"The Spectrometric Examination of Certain Fixed Oils as a Means of Identification." By H. C. T. Gardner.

The author's observations go to show that mere spectroscopic examination of a fixed oil is not of itself sufficient, but that evidence of identification can be obtained, in the case of certain oils, by measuring the positions of the terminations of visibility, together with the extent of visibility of the absorption spectra of various oils. Generally dissimilar oils exhibit dissimilar limits of visibility of their spectra.

NOTES.

Royal Institution.—A General Meeting of the Members was held on June 6, Sir James Crichton-Browne, Treasurer and Vice-President in the Chair. Miss G. Caton-Thompson, Sir John Collie, Mr. N. G. Hallett, Dr. H. R. Le Sueur, Mrs. Sidney Turner, Mr. J. Whitehead, and Dr. Leonard Williams were elected Members. The special thanks of the Members were returned to Sir Humphry Davy Rolleston for his present of a safety lamp which was in the possession of Dr. John Davy, brother of Sir Humphry Davy, and to Sir David L. Salomons for his present of a privately-printed "Life and Study of the Works of Breguet, the famous Watchmaker"; Arago's watch and two others of special interest, the first working aneroid made by Vidi in 1857, and a series of models illustrating the development of the chick.

Conjoint Board of Scientific Societies.—The Fourth Report of the Conjoint Board shows that the Board has received evidence that scientific investigation is being seriously hampered by the heavy cost involved in the publication of results. An exceptional number of papers are being communicated to the scientific societies, including many held up during the war, while the resources of the societies, which have not increased, are insufficient at present prices to publish even the normal pre-war number. The country is thus in

danger of being seriously handicapped at a time when the rehabilitation of industry is in most serious need of scientific assistance. Much of the Report is occupied with a short abstract of the Third Report of the Committee on the "Water Power of the Empire." It is shown that too little is being done to ascertain the total resources, or to secure uniformity in investigation and record. It is urged that steps should be taken to convene an Imperial Water Power Conference in London, at which the various Dominions and Dependencies of the Empire should be represented. The outcome of such a conference might well be the creation of an Imperial Water Power Board with extensive powers to carry out a comprehensive policy for stimulating, co-ordinating, and where necessary assisting development throughout the Empire. The Board has also dealt with questions relating to the formation of National Reserch Committees, in connection with the International Research Council formed in 1919, with the collection of scientific data in the former German colonies, and with instruction in technical optics. The research on glues and other adhesives initiated by the Board as a war measure, at the instance of the Air Ministry, has now been taken over by the Department of Scientific and Industrial Research.

TENDERS INVITED FOR CALCIUM CARBIDE.—Tenders are invited up to noon on July 15 next by the Egyptian Postal Administration at Alexandria for the supply of 15,000 kg. of calcium carbide for acetylene gas light plants. Quotations should comprise free storage at the sole risk of the contractor, and free delivery (by periodical partial supplies during the year) at 62 railway or river stations specified. Representation by a resident local agent is necessary, but United Kingdom firms not represented may care to avail themselves of the services of firms with an Egyptian branch whose names can be obtained at the Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. A copy of the above-mentioned specification is also available for inspection by United Kingdom manufacturers on application to the Enquiry Room of the Department.

ARTIFICIAL RESIN.—The artificial resin of C. C. Böhler is prepared by heating anhydroformaldehydaniline singly or mixed with small quantities of acids or alkalies, organic or mineral, at 100° to 200° C., and causing a reaction of vulcanising reagents, during formation of the resinous substance, especially sulphur chloride, with the mixture of reaction or the final product. Example: Heat 100 parts of anhydroformaldehydaniline, ½ part concentrated HNO_3 and 1 part sulphur chloride first to expel water, and then until the moment of obtaining the degree of hardness and fusion point required, at 100° to 200° C. For vulcanisation sulphur and selenium can be employed or their soluble compounds.—*Matières Grasses*, Feb. 15, 1921.

CATALYTIC HYDROGENATIONS ON COPPER.—One of the experimenters, Messrs. P. Sabatier and Bennosuke Kubota, demonstrated that copper obtained by slow reduction at 200° C., of hydrated copper oxide was a hydrogenating catalyser ("La Catalyse," 2nd edition). Continuing this study, the authors demonstrate that the aldehydes and aromatic cetones lead to carbides. With acetophenone one obtains ethylbenzene at 350° C. Hydrogenation of benzoquinone gives hydroquinone; that of phtalic anhydride phtalides with toluene, carbon monoxide and water.—*Comptes Rendus*, March 21, 1921.

RECORDING CHEMICAL REACTIONS ACCOMPANIED BY PRESSURE, BY PHOTOGRAPHY.—Temperature of the reaction and corresponding pressure can be simultaneously recorded (P. Jolibois). The pressure is measured with an electric current intensity which is recorded by photography of the spot of a galvanometer. For this purpose a well-gauged platinum wire is placed in the manometer, inserted in the circuit of a Daniell element. When the mercury rises in the manometer, the length of the wire is diminished, and consequently the resistance of the circuit. Intensity increases with pressure. A clock which periodically breaks the luminous pencil enables one to mark the time on the clichés.—*Comptes Rendus*, March 29, 1921.

NOTES AND QUERIES.

A CORRESPONDENT asks for information as to the process employed for producing a frosted or silky surface upon glass by means, other than sand-blasting.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by JORDAN & SONS, LIMITED, Company Registration Agents, Chancery Lane, W.C.2.

SIDUCOS, LIMITED.—(174863)—Registered 25th May, 1921. To carry on the business of Chemists and Druggists. Nominal Capital: £10,000 in 10,000 Shares of £1 each. Directors: To be appointhd by Subscribers. Remuneration of Directors: £50 each. Chairman: £100. Subscribers: H. H. Walton, 275, Croxted Road West, Dulwich, S.E.; M. Hackforth-Jones, Arkley House, Barnet, Herts.

T. W. RANSON, LIMITED.—(174867)—Registered 25th May, 1921. 7, Brazennose Street, Manchester. To carry on the business of Manufacturers and Dealers of all kinds of Chemical inclnding Manures, Bones, Slag and Substances allied thereto. Nominal Capital: £5,000 in 5,000 Shares of £1 each. Directors: T. W. Ranson, Westwood, Church Road, Urmston; P. A. Ranson, Westwood, Church Road, Urmston. Qualification of Directors: £1. Remuneration of Directors: To be voted by Company.

W. J. LEWIS, LIMITED.—(174838)—Registered 23rd May, 1921. 3, Hinckley Road, Leicester. To acquire and carry on the business of Pharmacists and Dispensing Chemists. Nominal Capital: £5,000 in 5,000 shares of £1 each. Directors: E. A. A. Fry, 65, Hoard Road, Leicester; S. J. Farr, 35, Herschell Street, Leicester. Qualification of Directors: 100 Shares. Remuneration of Directors: To be voted by Company.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

13981—Chemische Fabrik vorm Sandos.—Process for manufacture of a new preparation of hexame-thylenetetramine. May 18th.

13812—Nitrogen Corporation.—Preparation of hydrogen and ammonia. May 17th.

14035—Soc. Anon. de Produits Chimiques Etablissements Maletra.—Continuous production of sulphates. May 19th.
14049—Soc. Anon. de Produits Chimiques Etablissements Maletra.—Process for production of acetaldehyde from acetylene. May 19th.

Specification published this Week.

163162—Ellis, G. B.—Purification of ammonium salts.

Abstract Published this Week.

Lithopone.—Mr. R. Le Baker of St. Louis, U.S.A., has been granted a Patent No. 161280 in this country for an improved process of obtaining lithopone by the mutual precipitation of zinc sulphate and barium sulphide, the zinc sulphate solution is first freed from iron by a preliminary heat and oxidation treatment in the presence of an alkaline-earth peroxide such as barium or calcium peroxide and lead or zinc monoxide. The zinc-sulphate solution in the tank which is fitted with an agitator and is supplied with steam from a pipe, and compressed air from the tank, is treated with the powdered peroxide and zinc or lead monoxide in the proportion of about 1 per cent of the zinc sulphate in solution. The liquor is then passed through the filter-press to the tank where it is again treated with steam and air. After filtration which does not move the finely divided hydrated zinc oxide, the liquor is mixed with an equivalent quantity of barium sulphide solution in tank. The resulting precipitate is filtered off, washed, dried, calcined, quenched in cold water and ground wet. After another washing the pigment is filtered and dried.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK.

Wednesday, June 15.

Royal Microscopical, 5.

Thursday, June 16.

Royal Society. "Velocity of Sound in Gases at high Temperatures, and the Ratio of the specific Heats," by H. B. Dixon, Colin Campbell and A. Parker. "The Ratio of the specific Heats of Air and of Carbon Dioxide," by J. R. Partington. "'Light Body' Hydrophones and the directional Properties of Microphones," by A. B. Wood and F. B. Young. "Acoustic Disturbances produced by small bodies in Plane Waves transmitted through Water, with special reference to the single Plate Direction Finder," by A. B. Wood and F. B. Young. "Some Problems connected with Evaporation from large Expanses of Water," by M. A. Giblett. "The Photographic Efficiency of Heterogeneous Light," by F. C. Toy.
Chemical Society, 8.

Friday, June 17.

Royal Institution, 9. "Chemical Combination and the Structure of the Molecule," by Sir J. J. Thomson.

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All communications for this Department should be addressed to—

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UNIVERSITY OF GLASGOW.

APPLICATIONS are invited for a Lectureship in Organic Chemistry; salary £400 to £450 according to qualifications. Applications, stating teaching and research experience and giving the names of three references, to be sent as soon as possible to Prof. T. S. PATTERSON. Any available copies of testimonials may also be sent.

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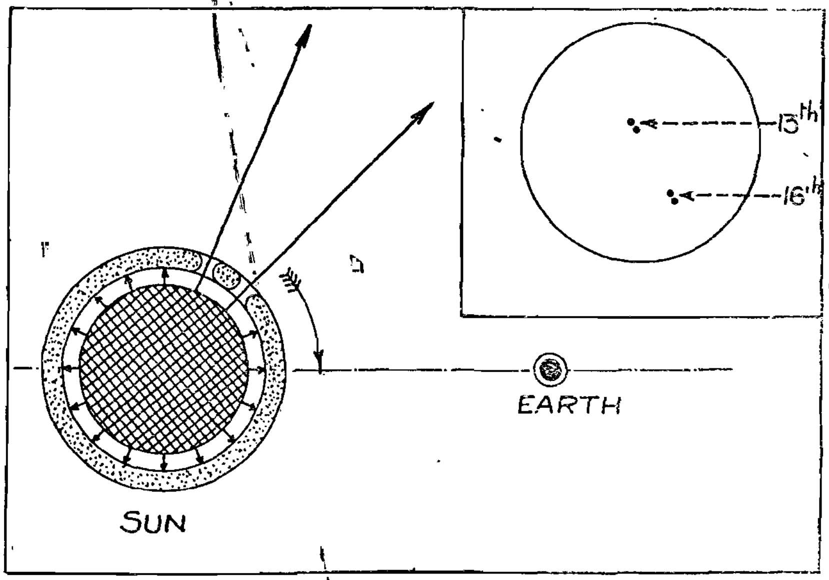
ATOMIC ENERGY AND SOLAR RADIATION: SUN-SPOTS AND AURORA.

By F. H. LORING.

THE origin of the aurora in the polar regions where the magnetic pole plays an important part in giving rise to various electrical effects, as seen in the vacuum tube, has led to certain investigations of this phenomenon. Some of these experiments will be briefly noted below; but first, an early account of the aurora itself, as given by Humboldt, is of interest, and it will serve to remind the reader of the complexity and beauty of the phenomenon.

"An Aurora Borealis [*Northern Light*, or *Polar Light*; there is also an *Aurora Australis*] is always



preceded by the formation in the horizon of a sort of nebular veil, which slowly ascends to a height of 4°, 6°, 8°, and even 10°. It is towards the magnetic meridian of the place that the sky, at first pure, commences to get brownish. Through this obscure segment, the colour of which passes from brown to violet, the stars are seen as through a thick fog. A wider arc, but one of brilliant light, at first white, then yellow, bounds the dark segment. Sometimes the luminous arc appears agitated for entire hours by a sort of effervescence and by a continual change of form before the rising of the rays and columns of light which ascend as far as to the zenith. The more intense the emission of the polar light the more vivid are its colours, which from violet and bluish-white pass through all the intermediate shades of green and purple-red. Sometimes the columns of light appear to come out of the brilliant arc mingled with blackish rays similar to a thick smoke. Sometimes they rise simultaneously in different points of the horizon; they unite themselves into a sea of flames, the magnificence of which no painting could express, and at each instant rapid undulations cause their form and brilliancy to vary. Motion appears to increase the visibility of the phenomenon. Around the point in the heaven which corresponds to the direction of the dipping needle, the rays appear to assemble together and to form a boreal corona. It is rare that the appearance is so complete and is prolonged to the formation of the corona, but when the latter appears it always announces the end of the phenomenon. The rays then become more rare, shorter, and less vividly coloured. Shortly, nothing further is seen on the celestial vault than wide, motionless, nebulous spots, pale, or of an ashy colour; they have already disappeared when the traces of the dark segment, whence the appearance originated, are still remaining on the horizon."

De la Rive was probably the first one to suggest that the aurora was an electrical effect as exhibited in Geissler's tubes, especially under the modifying influence of a magnet.

Sabine showed that there is a period of maximum frequency of magnetic storms and aurora which coincide with the maximum appearance of sun-spots.

Birkeland devised experiments by which he demonstrated that the magnetic storms could be imitated by placing a spherical body with magnetic poles—termed a *terrella*—inside a vacuum tube, the cathode representing the sun. For example, during an equatorial storm when the horizontal magnetic component is decreased, the conditions can be demonstrated by means of the terrella, which corresponds to the earth. In this case the cathode rays encircle its magnetic equator.

Störmer, in co-operation with Birkeland, worked out the trajectories of the electrified particles on entering the earth's field, the results of which support Birkeland's theory that the phenomenon arises from charged particles ejected from the sun.

Villard, in 1906, showed that cathode rays, as

AGRICULTURAL COLLEGE AND RESEARCH INST

influenced by a magnetic field, give rise to effects identifiable with those of the aurora. D. Owen gives in his book ("Recent Physical Research," 1913, chap. vi.) an account of some of the above experiments. See also Rutherford, "Radioactive Substances and their Radiations," 1913, p. 654; the following references to literature being given: Birkeland, *Arch. d. Sci. Geneva*, 1896; The Norwegian Aurora Polaris Expedition, 1902-3; Störmer, *Arch. d. Sci. Geneva*, 1907, 24; Vegard, *Phil. Mag.*, 1912, xxiii., 211; Darwin, *Nature*, 1903, lxviii., 496.

V. M. Slipher (*Astrophys. Journ.*, 1919, xlix., 266) gives evidence of the constancy of the phenomenon indicating that normally the sun emits (according to the views here presented) a sufficient number of electrified particles to cause weak effects—in fact, in polar regions the aurora is a regular occurrence. Slipher states that during a period of 3½ years, 100 spectrograms were taken at the Lowell Observatory, of the night sky, and each one gave the chief auroral line. The wave-length of this line was found to be 5578·05. It had been thought that this line was due to the nitrogen pair λλ 5560-5565 (see Stark, *Ann. d. Physik*, 1918, liv., 598), but this supposition seems no longer tenable.

Passing now to sun-spot phenomena, the following from the *Encyclopædia Britannica* will serve to introduce the subject: "Each spot shows, as a rule, one or more spots or groups of spots. Each spot shows with more or less completeness a ring-shaped penumbra enclosing a darker umbra; the umbra, which looks black beside the photosphere is actually about as brilliant as lime light." This appearance can be illustrated by dropping a drop of blue-black ink on a piece of paper; and, after blotting, dropping a small drop of Indian ink on top of the spot so as to leave a blue-black margin. This margin, of course, represents the penumbra.

A. L. Cortie (*Astrophys. Journ.*, 1907, xxvi., 123), referring to the band spectra, due to radiation from sun-spots, and their identification as flutings, remarks on the existence of chemical compounds. For bands at the extreme red have been identified by Hale and Adams (see W. S. Adams, *Astrophys. Journ.*, 1909, xxx., 86) as produced by titanium oxide, and later, Fowler has ascribed the bands in the green part of the spectrum to magnesium hydride. The observed change in the spectrum of Mira Ceti—as the brightness and temperature of this star had increased, its band spectrum had gradually changed more to a line one—affords evidence that the band spectra of the sun-spots indicate a temperature of the vapour therein which is lower than that of the photosphere.

Referring to the upper figure of the accompanying diagram, this represents the spots as they appeared during the interval, May 13-16, 1921, when seen through an opera-glass, the sun being low, and slightly dimmed by haze. The change in position seems to agree with the sun's rotation (25 days, 9 hours, 7 minutes), but no attempt is made to produce an accurate drawing. Accompanying the recent auroral display there was a magnetic storm of unusual violence, which was recorded in the Press at the time.

Referring to the other diagram (not drawn to any particular scale, and not intended to conform to any detailed features of the sun's structure, some of which are superficially known) it will be seen that as the spots revolve, the ejected matter (see previous paper in this Journal, vol. cxxii., p. 219) represented by the long arrows, will pass within range of the earth and come under the influence of its magnetic field, so that, assuming the ejected matter to be electrically charged particles, when they strike into the earth's atmosphere, they will give rise to the aurora.

The blackness of the spots, perhaps, has a partial analogy in the Faraday and Crookes dark spaces, as seen in vacuum tubes, especially as according to the views here advanced the whole phenomenon is a bombarding process involving positive-rays, or atomic nuclei and probably negative electrons. The radial arrows shown in the figure are intended to illustrate the bombardment or general course of these rays.

There seems to be some evidence that the sunspots are due to a species of eruption which has its origin in the nucleus of the sun. A gas composed of the above-mentioned particles might accumulate in large quantities in the central part or core of the sun, and work out gradually to the surface. The sunspot period of maximum activity is 11 years, which corresponds to about 158 revolutions of this body on its axis.

A thinning of the envelope may take place at times or in areas, and considerable quantities of the particles of disintegration may pass completely away from the sun. This would perhaps account for magnetic storms when the spots are not in particular evidence, and certainly it would seem to account for the auroral line always being present in the night sky.

The spots show evidences of being centres of powerful cyclonic disturbances, but the entire surface of the sun is in violent agitation, and the prominence flames have been known to extend outwards 150,000 miles. The whole phenomenon is on such a gigantic scale one can hardly realise its magnitude. The spots themselves are often thousands of miles across. In the recent display their widest part was reported to be 80,000 miles.

The reader should, of course, bear in mind that any views advanced which are not yet supported by reliable and repeated experiments are subject to modification, when new evidence is available.

Summary.

It was previously suggested that atomic nuclei and electrons were ejected from the more central part or nucleus of the sun owing to a pressure effect therein. It is now further suggested that some of these particles from the nucleus of the sun escape more or less radially through rifts in the solar envelope (which are the sun-spots) and when these particles enter the earth's atmosphere the aurora is produced in accordance with the ideas of Birkeland and others. The recent sunspot activity, together with the accompanying magnetic storm and aurora, is referred to.

Notes.

Referring to my previous paper (*loc. cit.*), the following notes should be associated therewith:—

(*a*) No mention was made of hydrogen in the sun—of course, it is present in considerable quantities.

(*b*) Probably lithium is present in the sun. See A. S. King, *Astrophys. Journ.*, 1916, xliv., 169.

(*c*) The idea of the nuclear parts of atoms coming into conflict due to pressure was discussed. It

is of interest to note C. A. Parsons' (*Inst. of Metals Journ.*, 1918, xx., 5) account of his attempts to produce diamonds. In these trials, a steady pressure of 15,000 atmospheres per sq. inch, with a momentary pressure twenty times as great was obtained, and it was stated to be about one-half that at the centre of the earth, while in many stars the pressure would be enormously greater. This value would be "only a fraction of one-thousandth part of the pressure at the centre of the large stars." In one experiment in which a steel piston was driven by the explosion of powder against a gas charge of oxygen and acetylene contained in a bored steel block, the pressure was supposed to be about 15,000 atmospheres per sq. inch, and the instantaneous temperature reached 17,700° C. (calculated). See in this connection Chemical News, 1921, cxxii., 235: a method proposed by Parsons to reach very high instantaneous pressures.

(*d*) From certain mechanical or kinetic considerations, perhaps it is not correct to consider such enormous pressures, as suggested in the case of the disintegration of atoms in the sun, to act entirely as a displacement blow or shear, and consequently *spin energy*, as it might be termed, may become a factor. Then, in turn, centrifugal force would have to be taken into account. However this may be, besides this latter consideration, the favourable chance positions of the atoms or their nuclei possibly enter into the problem.

Corrections.—In my communication on page 169 of this volume, a faulty sentence occurred in the tenth paragraph. It should read: "This experimental work is of very far-reaching significance, and it is especially important in affording a powerful tool for investigating sub-atomic phenomena and revealing secrets which some years ago one would have considered beyond the power of man to discover."

On page 219 of this volume, eighth paragraph, in two places the Greek letter "α" should be inserted before the word -particles. This, of course, was a typographical error.

THE MECHANISM OF FLOCCULATION IN SOILS.*

By NORMAN M. COMBER, B.Sc., A.R.C.S., A.I.C.

The texture of a mineral soil is determined by two chief factors, namely, the size of the particles and the arrangement of the particles.

The size of the ultimate particles is manifestly permanent and unalterable for all practical purposes. Information regarding this factor is of great importance, and for the purpose of obtaining and expressing such information the soil particles are conventionally graded. In this country it is customary to divide all particles capable of passing a 3-mm. sieve into six "fractions," namely:

		Diameter. mm.
1.	Gravel	3·00–1·00
2.	Coarse sand ...	1·00–0·20
3.	Fine sand ...	0·20–0·04
4.	Coarse silt ...	0·04–0·01
5.	Fine silt	0·01–0·002
6.	Clay	below 0·002

*A Contribution to a General Discussion on "Physico-Chemical Problems Relating to the Soil" held by The Faraday Society, on Tuesday, May 31, 1921.

The finer fractions are separated by sedimentation; the coarser ones by sieving.

The arrangement of the particles in a soil is by no means permanent, but is liable to relatively rapid changes. Besides the obvious rearrangement which will be caused by compressing or by loosening the soil, the smallest particles (the fine silt and the clay) become under certain conditions aggregated together to produce what is, in practical effect, a lesser number of larger particles and a consequent lightening of the soil. This aggregation or flocculation process is affected by a number of conditions such as freezing and thawing, sun-drying, and the presence of electrolytes. It is reversible, and deflocculation follows the removal of the factor causing flocculation.

In this paper it is proposed to offer some observations regarding this flocculation process as it is brought about by electrolyte in general, and by lime in particular.

The Effect of Fertilisers on Soil Texture.

It is well established by experience and experiment in the field, that the addition of certain fertilisers has an effect upon the soil texture. Thus, the excessive or prolonged use of nitrate of soda (which has been shown by Hall (see "The Book of the Rothamsted Experiments," 1919, pp. 295-305) and his co-workers to give rise to sodium carbonate in the soil) is known to enhance the stickiness of a soil, and to so deflocculate the clay that it is removed in measurable amount in a turbid drainage water. Laboratory experience abundantly confirms the field observation that small amounts of alkaline substances, such as the carbonates and hydroxides of sodium potassium and ammonium, deflocculate soil clay, giving it the power of remaining in suspension almost indefinitely, making it very difficult to filter, and rendering it extremely sticky when in mass.

By far the most striking and the most important case which arises in agricultural practice is the amelioration of the texture of clay soils which results from the addition of lime. It is established by the experience of many generations that dressings of lime of the order of one to two tons to the acre greatly diminishes the stickiness of a clay soil, reduces the plough draught, and facilitates drainage. The laboratory examination of the subject shows that this action of lime is due to the aggregation or flocculation of the particles.

In farming practice, however, it is not an invariable rule that lime thus improves the texture of all heavy soils. Field experience shows that there is a distinction between heavy soils which respond, in respect of their texture, to dressings of lime and those which do not so respond; and this distinction is found to coincide with that between heavy soils containing a dominant amount of the clay fraction and those whose heaviness is due to a dominant amount of the fine silt fraction. *Clay is readily flocculated by lime, fine silt is not.*

The Flocculation of Soils and the Isoelectric Point Theory.

There have been very many investigations of the power of various electrolytes and colloids to flocculate suspensions of soil particles and of kaolin. In general the results indicate a process analogous to the flocculation of suspensoid sols, and which admits of explanation on the basis of the isoelectric point theory.

For instance, if a series of similar suspensions of soil particles is treated with colloidal ferric hydroxide in amounts which gradually increase from one end of the series to the other, a point of optimism and immediate flocculation can be found, and amounts of the positive sol greater or less than that producing the optimum flocculation, have less effect. Similar results can be obtained by the use of ferric chloride, aluminium hydroxide, and aluminium chloride (the details of these experiments will shortly be published elsewhere). Such results are analogous to those obtained by Burton in the flocculation of metal sols by aluminium salts (see Burton, "The Physical Properties of Colloidal Solution," 1916).

Again, with electrolytes as flocculants the valency rule is applicable as well to the flocculation of soil suspensions as to that of suspensoid sols. Hall and Morison (*J. Agric. Sci.*, 1907, ii., 244) in a careful investigation of the flocculation of kaolin suspensions certainly failed to elicit the quantitative requirements of Whetham's theory, but they showed quite clearly that the trivalent kations of salts had a flocculating power superior to that of divalent kations which in turn were more effective than monovalent kations.

The flocculation of soil particles appears therefore to fall fairly well into line with the flocculation of suspensoid sols and, with the flocculation of these sols, to be amenable to the isoelectric point theory. There is, however, one well-known exception which happens to be the only case of soil flocculation which is of great practical importance. The flocculation of clay by lime does not appear compatible with the electrical theory, since the hydroxyl ion will, according to the theory, tend to stabilise the suspension.

The Flocculation of Clay by Lime.

The explanation of this anomalous case of flocculation which is commonly advanced is that lime added to the soil becomes converted into calcium bicarbonate which latter compound then acts as the flocculant. This explanation is, however, difficult to accept for several reasons of which the following are the chief :—

(1) It affords no explanation of the difference between the action of lime on clay and on fine silt.

(2) If two similar clay suspensions are treated, one with calcium hydroxide and one with calcium bicarbonate in equivalent amount, flocculation is much more rapid in the former case. (The reverse is true of suspensions of fine silt, and, as shown by Hall and Morrison, of kaolin).

The present writer has examined the effect of alkalinity on the flocculation, by calcium salts, of clay and fine silt suspensions (Comber, *J. Agric. Sci.*, 1920, x., 425). It was found that *the flocculation of clay by calcium nitrate is greatly enhanced by the addition of a small amount of ammonium hydroxide, while the flocculation of fine silt by calcium salts is retarded by the addition of alkali.* It must also be noted that the volume of the coagulum is noticeably large when compared with the volume of the coagulum formed by neutral salts.

It seems clear, then, that the flocculation of clay by lime is a genuinely abnormal case in which the hydroxyl ion actually facilitates the action.

The Mechanism of Flocculation in Soils.

In endeavouring to find an explanation of clay flocculation in general, and of the abnormal effect of alkalinity upon the flocculation of clay by the calcium ion in particular, it is necessary to bear in mind two important and pertinent facts about clay, namely :—

(1) Clay is very reactive. With solutions of neutral salts it enters into the process of base exchange, and for this reason the flocculating effect of salts is not to be interpreted as necessarily and entirely a direct effect of the kation of the particular salt used. Also, clay is readily susceptible to dissolution by acids, and flocculation by acids will be complicated accordingly.

(2) The clay particle in water does not present a sharp, solid-liquid surface. The relationship of clay to water is different from that of other soil fractions, kaolin and ignited clay (see Keen, *J. Agric. Sci.*, 1920, x., 44), and the peculiarities of clay in this respect strongly indicate that the clay particle is related to the water through the intermediation of organic and siliceous colloidal matter. Unignited soil clay seems to stand apart from other fractions and from kaolin by reason of its marked protection by "emulsoid" material.

Taking cognisance of these two facts about clay—its reactivity and its protection (regarding protection of clay by humus, see Sven Oden, *J. für handwirt*, 1919, p. 177)—it seems clear that three cases of flocculating action may be possible, namely :—

1. *Direct flocculation* in which the flocculant acts in the same manner as on unprotected and non-reactive suspended particles, the action being merely diminished or delayed by reason of the protection.

There are probably few, if any, cases in which the flocculation of clay is exclusively of this type. The action of iron and aluminium salts and of the colloidal hydroxides of iron and aluminium may be predominantly a direct action. A concentration of these flocculants which produces a maximum effect is easily observable, and in this respect the phenomenon seems to be analogous to the flocculation of metal soils.

2. *Indirect flocculation* in which the products of a previous reaction, such as base exchange or dissolution, act as flocculants.

When neutral salts are used as flocculants it seems assured that the action is to some extent of this second type. There is invariably a partial exchange of kations when neutral salt solutions are in contact with clay, the base exchange process is very rapid, and it appears inevitable therefore that some part of the occulating action is due to the kations brought into solution from the clay.

The flocculation of clay by acids seems also to be largely indirect and attributable to the action of aluminium, &c., dissolved by the acid from the clay. In the flocculation of kaolin, Hall and Morrison (*loc. cit.*) found that mineral acids were slightly better flocculants than aluminium salts, and suggest that the flocculating power of the latter may be partly due to the acid formed by hydrolysis. With soil clay the case seems to be the reverse of this. Using hydrochloric and aluminium chloride in one set of experiments, and sulphuric acid and aluminium sulphate in another, and using several different clays, the present writer has found that the aluminium salts flocculate soil clay much more rapidly than the corre-

sponding acid in equivalent amount (the details of these experiments will shortly be published elsewhere). It is therefore suggested that the action of acids may to some extent be ascribed to the bases they bring into solution.

3. *Abnormal flocculation* in which the flocculant reacts with the protecting emulsoid matter forming a coagulum which entrains the particles.

This type of clay flocculation seems to be of greatest agricultural importance, for it appears to provide a feasible explanation of the abnormal flocculation of clay by lime, the fact of which has been described above.

When calcium hydroxide is added to a dilute silicic acid sol, a gelatinous precipitate is formed. This precipitate is not formed when a *neutral* calcium salt is added to the neutral sol: it is produced by the action of calcium ions only when the medium of action is alkaline. The precipitate has been investigated by Le Chatelier ("La Silice et les Silicates," 1914), who found that it consisted of silica with varying amounts of lime, and that the lime is easily and entirely removed by washing. Another feature of this precipitate is its enormous volume: according to Le Chatelier 1 grm. of it settles to occupy a volume of 2 litres.

Now if the protection of clay particles is in part due to colloidal silica, which seems certain to be the case, then the addition of lime—the addition of calcium ions and hydroxyl ions—will produce a precipitate such as that described. The production if such a precipitate, entraining the particles seems to be a satisfactory explanation of the flocculation of clay by lime. It accounts for the fact that alkalinity facilitates the flocculation since the formation of the precipitate is dependent upon alkalinity. It accounts for the reversibility of the action since the precipitate is hydrolysed by washing. It accounts for the large volume of the clay coagulum since the precipitate is phenomenally voluminous. Further, this theory of the abnormal flocculation of clay by lime, postulates nothing about clay other than a siliceous emulsoid protection which is already strongly indicated by quite independent considerations.

The effect of small amounts of colloidal silica on the flocculation of finely divided particles in suspension was examined by using a sample of oxide of iron in the form of an impalpable powder. The oxide of iron, when shaken with pure water, did not remain long in suspension, but traces of silicic acid sol gave not only stability to the suspension but also the power of being flocculated by calcium salts much more readily in the presence of alkali than in neutral suspension. It was found in one case that 0·6 mgrms. S_1O_2 was able to affect 300 mgrms. of the oxide of iron in this respect. Evidently, therefore, very small amounts of colloidal silica in conjunction with finely divided particles can produce a system susceptible to the abnormal flocculation which is found in the case of clay.

While, then, the mechanism of flocculation in soils does not generally appear to be essentially different from that of the flocculation of suspensoid sols, the flocculation of clay by lime is a process of a distinctly different type. Using the prevalent terminology it is an "emulsoid" phenomenon and is quite out of line with the flocculation of "suspensoids." As an emulsoid phenomenon it appears to be explicable on the basis of the reaction between calcium hydroxide and colloidal silicic acid, and the assumption, which that explanation involves, of a particular colloidal condition which differentiates clay from other soil fractions and from kaolin, is consistent with the peculiarities of clay which have been brought to light by other investigations.

THE PURIFICATION AND SOME PHYSICAL PROPERTIES OF CERTAIN ALIPHATIC ALCOHOLS.

By ROGER F. BRUNEL, J. L. CRENSHAW and ELISE TOBIN.

Concluded from 271.)

Iso-Butyl alcohol.—Boiling point: (1) thermo-element: boiled 4 hours with barium oxide, 107·877°; distilled from barium oxide without long boiling, 107·874-107·888°; aluminum amalgam, 107·881°; (2) obtained by the authors at the Bureau of Standards, 107·89°.

The data for distillation of two specimens follow. A third specimen was worked up from residues.

(A) 265 g.: I., below 107·86°, 15 g.; II., 107·86-107·89°, 48 g.; III., 107·89, 170 g. (B) I., 107·88-107·89°, 14 g.; II., 107·89°, 66 g.

Particular attention is called to the densities of this alcohol, seen in the table below. In this case the density is of little value as a criterion of purity.

sec.-Butyl alcohol.—Since the thermometers gave concordant values for the boiling point and our supply of this alcohol was limited, it was not tested with the thermoelement. The thermometer readings are especially relable since thy lie so close to the 100° point. (1) Thermometers: 99·52°, 99·53°, 99·53°.

This was one of the alcohols most readily purified. The data in the table below appear to be sufficient.

Methyl-iso-butyl carbinol: Aluminum amalgam dries this very slowly, partly, at least, because of the slight reactivity of the drying agent with the alcohol itself. After several hours' boiling a large part of aluminum had still not reacted. In addition to this, the boiling point of the alcohol is so far above 100° that the water has a particular tendency to distil out of the alcohol and collect in the condensed liquid in the cooler parts of the apparatus. It is difficult to prevent this altogether since too prolonged, vigorous boiling causes too much loss of vapour around the ground-glass stopper of the apparatus.

The values obtained were from 131·78° to 131·826°, and the higher value is more likely to be correct. The value obtained at the Bureau of Standards was much too low. The values on our thermometers were also unsatisfactory, varying from 131·77° to 131·85°. The value 131·82° must be nearly correct.

This alcohol was easily purified. A good deal came over within 0·01° on the first distillation, and 72 per cent of this, on redistillation, came over constantly. This, and other constant boiling portions were distilled as follows:—

(A) wt., 320 g. I., Below 131·79° less than 1 g., total to 131·81°, 12 g.; II., 131·81°, 73 g.; III., 131·81°, 166 g.; IV., 131·81°, 50 g.; II., III., and IV., 289 g.

TABLE I.

1 Specimen	2 Const. boiling portion. % of total	3 % of part distd.	4 dt/dP.	5 B.p. °C.	6 d^{25}_{4}	7 η^{D}_{25}	8 M^{D}_{25}
			Ethyl Alcohol.				
		100	0·035	78·32	0·78505	1·3595	12·93
			n-Propyl Alcohol				
A	56	78	0·036	97·19	0·79975	1·3833	—
B	47	63	—	—	0·79992	1·3832	—
Most probable values:				97·19	0·7998	1·3833	17·54
			Iso-Propyl Alcohol.				
A-III	84	87	0·033	82·26	0·78089	1·3750	—
IV.			—	—	0·78167	1·3750	—
B	70	81	—	—	0·78071	1·3749	—
C	—	57	—	—	0·78072	1·3748	—
D (Res.)	—	56	—	—	0·78086	1·3749	—
Most probable values:				82·26	0·7808	1·3749	17·61
			n-Butyl Alcohol.				
A	—	90	0·036	117·71	0·80560	1·3974	—
B-V.			—	—	0·80566	1·3974	—
VI.	69	78	—	—	0·80571	1·3974	—
VII.			—	—	0·80586	1·3973	—
Most probable values:				117·71	0·8057	1·3974	22·17
			Iso-Butyl Alcohol.				
A	64	73	0·036	107·89	0·79800	1·3938	—
B	—	82	—	—	0·79800	1·3939	—
C (Res.)	72	77	—	—	0·79802	1·3939	—
Most probable values:				107·89	0·78801	1·3939	22·21
			sec.-Butyl Alcohol.				
A-III.	—	—	0·036	99·53	0·80270	1·39495	—
IV.	—	over 90	—	—	0·80276	1·39495	—
B	83	97	—	—	0·80267	1·39495	—
Most probable values:				99·53	0·80271	1·39495	22·1[illegible]
			Methyl-*iso*-Butyl-carbinol.				
A-II.			0·040	131·82	0·80251a	1·40895	—
III.	88	96			0·80238	1·40895	—
IV.	—	—	—	—	0·80250	1·40885	—
B	—	84	—	—	0·80243	1·40895	—
Most probable values:				131·82	0·825	1·40895	39·61

(a) The fractions of Specimen A were tested in very humid weather. Possibly the values should have been identical.

TABLE II.

Author.	B.p. °C.	d^{25}_{4}	η^{D}_{25}
	Ethyl Alcohol.		
Mendelejeff[1]	78·303	——	—
Ramsay and Young[2]	78·33	——	—
Noyes and Warfel[3]	78·30	——	—
Andrews[4]	—	0·78510	1·35941
Doroshevski and Dvorzhanchik[5]	—	——	(24°) 1·35927
Doroshevski and Polianski[6]	78·35	——	—
Wade and Merriman[7]	78·39	——	—
Osborne, McKelvy, and Bearce[8]	—	0·78506	—
Robertson and Acree[9]	—	0·785085	—
Richards and Coombs[10]	78·42	——	—
Authors' values	78·32	0·78505	1·3595
	n-Propyl Alcohol.		
Brühl[11]	97·3-·5	0·8005 (20°)	1·3836
Naccari and Pagliani[12]	—	0·8004	—
Perkin[13]	98	0·8001	—
Ramsay and Young[14]	97·4	0·7995	—
Landolt and Jahn[15]	96·1	0·8017 (17·8°)	1·3835
Loomis[16]	97·2	0·8000 (20°)	—
Young and Fortey[17]	97·19	0·7994 (0°)	—
Holmes and Sagemann[18]	97·2-·4	0·79972	—
Doroshevski and Rozhdestvenski[19]	97·26	0·7994 (20°)	—
Doroshevski and Dvorzhanchik[20]	—	——	(20°) 1·38365
Authors' values	97·19	0·7998[21]	1·3833

TABLE II. (*continued*).

	iso-Propyl Alcohol.		
Brühl[22]	82-83	0·7844 (20°)	1·3756
Zander[23]	82·7-·9	0·7794 (17°)	—
Perkin[13]	—	0·78220	—
Thorpe[24]	81·6-82·1	0·7811 (15°)	—
Louginine[25]	82·04	——	—
Doroshevski	82·42[26]	0·7807[27] (20°)	—
Doroshevski and Dvorzhanchik[20]	—	——	1·37534
Authors' values	82·26	0·7808	1·3749
	n-Butyl Alcohol.		
Kahlbaum[28]	117·6°	——	1·39747
Doroshevski and Dvorzhanchik[20]	117·1	——	1·39749
Authors' values	117·71	0·8057	1·3974
	iso-Butyl Alcohol.		
Perkin[13]	107·6-8·3°	0·79852	–
Traube[29]	—	0·8000 (20°)	—
Landolt and Jahn[30]	107·25	0·7987 (17·5°)	1·3941
Naccari and Pagliani[12]	—	0·7972	—
Doroshevski and Dvorzhanchik[20]	107·93	0·7976 (15°)	1·39396
Doroshevski[27]	107·5	——	—
Michael and Zeidler[31]	107·67-·75	——	—
Richards[32]	107·2-·3	——	—
Authors' values	107·89	0·79801[33]	1·3939
	sec.-Butyl Alcohol.		
Pickard and Kenyon[34]	99°	0·8039	—
Dogolenko[35]	—	0·8024-0·8031 (20°)	—
Authors' values	99·53	0·80271	—

The temperatures in parenthesis are those of the the original determinations, from which the values given were calculated.

References.—(1) *Z. Chem.*, 1865, 257. (2) *J. Chem. Soc.*, 1885, xlvii., 654. (3) *J. Amer. Chem. Soc.*, 1901, xxiii., 465. These authors state that they consider their value probably less reliable than that of Ramsay and Young. (4) *Ibid.*, 1908, xxx., 357. (5) *C.A.*, 1908, ii., 2181. (6) *Z. physik. Chem.*, 1910, lxxiii., 192. (7) *J. Chem. Soc.*, 1911, xlix., 1002. (8) *J. Wash. Acad. Sci.*, 1912, ii., 95. (9) *Am. Chem. J.*, 1913, xlix., 497. (10) *J. Amer. Chem. Soc.*, 1915, xxxvii., 1669. (11) *Ann.*, 1879, cc., 173. (12) *Atti. Accad. Sci. Torino*, 1881, xvi., 407. (13) *J. Chem. Soc.*, 1884, xlv., 466. (14) *Phil. Trans.*, 1889, clxxx., 140. (15) *Z. physik. Chem.*, 1892, x., 288. (16) *Ibid.*, 1900, xxxii., 594. (17) *J. Chem. Soc.*, 1902, lxxxi., 725. (18) *Ibid.*, 1909, xcv., 1936. (19) *J. Russ. Phys. Chem. Soc.*, 1910, xl., 1428. The formula of De Heen, which these authors recommend, was tested by them only between 10° and 20°. When tested by the results of Ramsay and Young, and Naccari and Pagliani for 0°, it is not as satisfactory as the formula of the latter authors, which we have used. (20) *C. A.*, 1909, iii., 1355. (21) Further tests of this value will be made with material now being purified. (22) *Ann.*, 1880, cciii., 12. (23) *Ann.*, 1882, ccxiii., 155. (24) *J. Chem. Soc.*, 1897, lxxi., 923. (25) *Ann. chim. phys.*, 1898, [7] xiii., 307. (26) *Centralbl.*, 1911, i., 465. (27) *C. A.*, 1910, iv., 1404. (28) *Z. physik. Chem.*, 1898, xlvi., 628, 646. This author gives d^{20}_{4}=0·80978. If we assume the temperature coefficient to be the same as that of *iso*-butyl alcohol, we obtain d^{25}_{4}=0·8059. (29) *Ber.*, 1886, xix., 883. (30) *Z. physik. Chem.*, 1892, x., 317. (31) *Ann.*, 1912, cdxciii., 93. (32) *J. Amer. Chem. Soc.*, 1915, xxxvii., 1669. (33) The density appears, in this case, to be easy to duplicate without a high degree of purity. Some years ago one of the authors (*Ber.*, 1911, xliv., 1004) obtained three fractions boiling, altogether, over a range of 0·24°, having densities of 0·79890 to 0·79802. (34) *J. Chem. Soc.*, 1913, ciii., 1940. Value for 25° by linear interpolation. (35) *Z. physik. Chem.*, 1908, lxii., 505. Values estimated from those given for 20° by comparison with Pickard and Kenyon's values.

Another specimen (B) distilled nearly as well. Table I. summarises the distillation data and physical properties of our specimens. Under Col. 2 will be found the per cent of the material taken for the final distillation, which came over at constant temperature. Values are, however, lacking in some cases due to failure to record the total weight before distillation. These values do not fairly represent the purity of the specimens, since they imply that the material remaining in the still would not have come over at the correct temperature, whereas all experiments with these residues indicated that the amount of high boiling impurity in them was small. More significant are the figures in Col. 3, which show the per cent of the amount actually distilled which was collected at constant temperature.

The "most probable values" are not always averages of the results, but are based upon our judgment as to the relative value of the tests or purity of the specimens. We believe the boiling points to be accurate to ±0·01°, except that of methyl-*iso*-butyl-carbinol. The refractivities appear to be accurate to 0·0001. In the case of the densities, however, while the determinations are accurate to 0·00002, the true densities of the substances have not been established, in most cases, nearer than 0·0001.

The values for dT/dp are given in degrees per mm. pressure. The values of the molecular re-

fractivity are calculated according to the equation:

$$M = \frac{\eta^2 - 1}{\eta^2 + 2} \cdot \frac{M}{D}$$

In Table II. we have quoted for comparison some of the values to be found in the literature. Among the older values we have included only those which were determined with particular care or which are often quoted. Densities have been recalculated to 25° where they were not determined at this temperature, and we have indicated in parenthesis the temperature of the original determinations in such cases. For alcohols where there is no basis for such calculation, the values are not given.

The reliability of the calculations of the densities is open to question, but the differences between the values are in most cases greater than the possible errors in calculation. The following appear to be the most reliable formulas (the references will be found in the table.

For *n*-propyl alcohol, a formula of Naccari and Pagliani, $d = 0{\cdot}8203 - at + bt^2 - ct^3$ where log a = 6·90228, log b = 3·66482, log c = 2·10469 (−10 after each), and 0·8203 is the density at 0°. This equation fits the values of Ramsay and Young (0°, 15°, 25°), Perkin (15°, 25°), Loomis (15°, 20°), and Doroshevski and Rozhdestvenski (10°, 20°), to within 0·0001, after calculation back to a value for d^0 in each case. (Although the density of the alcohols is affected by slight impurities, the form of the density-temperature curve is apparently not much affected).

For *iso*-propyl alcohol, one of the equations given by Zander, $V_t = V_0\ (1 + 0{\cdot}0010743t + 0{\cdot}06328t^2)$ which very nearly fits the values of Perkin (15°, 25°).

For *iso*-butyl alcohol the equation of Naccari and Pagliani, $d = 0{\cdot}81624 - at - bt^2 - ct^3$ where log a=6·87551, log b=3·43912, log c=1·86857 (−10 after each), and 0·81624 is the density at 0°. This equation fits the values of Perkin (15, 25°) very closely.

The refractivities can be calculated with more certainty, since Doroshevski and Dvorzhanchik showed that the formula $\eta_t = \eta_0 / (1 + kt)$ holds for the common alcohols. Where the refractivity has been determined for two temperatures, a value for k can be calculated. We have used for *n*-propyl alcohol, k=0·032368 (values of D. and D.); *iso*-propyl alcohol, $0{\cdot}0_3 2850$ (authors' values); *iso*-butyl alcohol, $0{\cdot}0_3 269$ (D. and D.).

No values are given in Table II. for methyl-*iso*-butyl carbinol. It has been prepared by Skita and Ritter (*Ber.*, 1910, xliii., 3397), Pickard and Kenyon (*J. Chem. Soc.*, 1911, xcix, 56), Guerbet (*Compt. Rend.*, 1909, cxlix., 129), and others, but, although its boiling point has been known to be in the neighbourhood of 131°, no determinations of its density or refractivity are recorded.

The authors acknowledge with pleasure the courtesy of the U.S. Bureau of Standards in providing opportunity for the first boiling point tests with one of their resistance thermometers, and, in particular, their indebtedness to Miss Amelia K. Benson, with whose assistance the tests were made.

They also take pleasure in acknowledging their indebtedness to the Warren Fund of the American Academy of Arts and Sciences for a grant which covered the cost of materials for this work, as well as for the preparation of several alcohols on which the work is not yet completed.—*Journal of the American Chemical Society*, March, 1921.

ELECTRIC OSCILLATIONS ALONG STRAIGHT LINES AND SOLENOIDS.*

By Prof. J. S. Townsend, F.R.S.

A number of experiments made by the author and Mr. J. H. Morrell to find the relation between the frequencies of the normal oscillations of systems are described.

As in the case of mechanical oscillations, it is necessary to distinguish between a series of free normal modes of oscillation and a series of harmonic oscillations. In the free oscillations of a system having distributed capacity and inductance there is, in general, no exact relation between the frequencies of the different modes of oscillation. A harmonic series of oscillations is obtained in nearly all cases where a fundamental oscillation of constant amplitude is maintained in a system, as, for example, when a tuning fork is maintained in vibration by an interrupted current, or a current is maintained in an oscillatory circuit by a thermionic valve.

The oscillations of solenoids and parallel wires are discussed, and an estimate of the accuracy obtained in measuring wave-lengths by wires is given.

A simple method, depending on harmonic oscillation, is described, whereby the lengths of short waves measured by means of parallel wires may be compared with those of long waves measured by means of standard inductances and capacities.

* Synopsis of Paper read before the Wireless Section of the Institution of Electrical Engineers, June 8, 1921.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, June 2, 1921

Prof. C. S. Sherrington, President, in the Chair

The Bakerian Lecture was delivered by Dr. T. M. Lowry, F.R.S., and Dr. C. P. Austin, on "*Optical Rotatory Dispersion.*" The following summary was supplied by the Lecturer:—

1. Although no case is known in which Biot's Law of Inverse Squares, $\alpha = k/\lambda^2$, is accurately true, the rotatory dispersion in a very large number of organic compounds can be expressed by the *simple dispersion formula*, $\alpha = k/(\lambda^2 - \lambda_0^2)$, which differs from Biot's formula only in the introduction of a "dispersion constant" λ_0^2.

2. This simple formula is a special case of the general formula $\alpha = \Sigma k_n'/(\lambda^2 - \lambda_n^2)$, introduced by Drude as an approximation based upon the electronic theory of radiation and absorption of light. Substances which require more than one term of this equation are said to show *complex rotatory dispersion.*

3. Tartaric acid and its esters give dispersion curves which frequently show (i.) an inflexion, (ii.) a maximum, (iii.) a change of sign, and are then described as cases of *anomalous rotatory*

dispersion. These can be represented by two terms of Drude's equation :—

$$a = \frac{\lambda^2 - \lambda_1^2}{k_1} - \frac{\lambda^2 - \lambda_2^2}{k_2}$$

The anomalies mentioned above only appear (i) when the two terms are opposite in sign; (ii) when $k_1 > k_2$, if $\lambda_2^2 > \lambda_1^2$. The wave-lengths at which the reversal, maximum and inflexion occur are given by

$$\frac{k_1}{k_2}\sqrt{,\frac{k_1}{k_2}} \text{ and } \sqrt{\frac{k_1}{k_2}} = \frac{\lambda^2 - \lambda_1^2}{\lambda^2 - \lambda_2^2}$$

4. The rotatory dispersion in quartz was represented by Drude by a two-term equation, in which the dispersion-constant of the negative term was negligible, so that

$$a = \frac{k_1}{\lambda^2 - \lambda_1^2} - \frac{k}{\lambda^2}$$

where $\lambda_1^2 = 0{\cdot}010627$, $k_1 = 12{\cdot}200$, and $k = 5{\cdot}046$. Since $k_1 > k$, the dispersion-curve is complex but not anomalous. In order to express the most recent measurements, it is necessary to assume finite values for both dispersion-constants, and to introduce a term to express the influence of the infra-red absorptions; the infra-red term is, however, very small and can be taken as a constant, so that

$$a = -k + \frac{k_1}{\lambda^2 - \lambda_1^2} - \frac{k_2}{\lambda^2 - \lambda_2^2}$$

where $\lambda_1^2 = 0{\cdot}012742$, $\lambda_2^2 = 0{\cdot}000974$
$k = -0{\cdot}1915$, $k_1 = 9{\cdot}5644$, $k_2 = -2{\cdot}3114$

5. The anomalous dispersion of tartaric acid was attributed by Arndtsen in 1858 to the presence of two modifications of the acid differing in the sign of their rotations and in the magnitude of their dispersions. This view has been confirmed (i) by the proof that the complex rotatory dispersion of the acid and its derivatives can be expressed as the sum of two simple dispersions; (ii) by the discovery of certain "fixed" derivatives of tartaric acid which exhibit simple rotatory dispersion. Attention is directed to some analogies between tartaric acid and nitrocamphor, which gives two isomeric compounds in solution.

PHYSICAL SOCIETY.

May 27, 1921.

PROF. SIR W. H. BRAGG, F.R.S., President, in the Chair.

A paper "*On the Reflection of the X-ray Spectrum of Palladium from Fluorspar,*" was read by Mr. H. PEALING.

An examination of the odd order spectra reflected from the 100 plane of fluorspar, using palladium X-rays has been made with a view to test the Lewis-Langmuir theory of the motion of valency electrons in compounds. Evidence, in partial confirmation of the theory, has been obtained.

DISCUSSION.

Prof. BRAGG said that the relatively high magnitude of the third order spectrum was most curious. There was evidently something diffracting strongly about a third of the way between the calcium and fluorine atoms: it was possibly only a coincidence, but this was where the junction of these atoms occurred.

Prof. RANKINE asked what was supposed to be the source of the diffraction, the nucleus or the electrons distributed round it. If the latter, what was the justification for assuming the diffraction to originate from the planes containing the nuclei?

Prof. BRAGG said the origin of the diffraction was what they were all trying to settle. Possibly the paper he was just about to read would answer Prof. Rankine's question.

Dr. HOPWOOD was not clear as to what the paper proved. Assuming the reflecting power of the calcium and fluorine atoms to be proportional to the atomic numbers the same magnitude for the faint spectra was apparently to be expected with or without the transference of electrons of the Lewis-Langmuir theory. This being so, he did not see that the result was evidence one way or the other.

Mr. PEALING said the discrepancy of the larger third order spectrum was more easily accounted for on the basis of the Lewis-Langmuir theory.

Dr. HOPWOOD thought this might be due to a single distortion rather than to a transfer of electrons from the calcium to the fluorine.

A paper on "*The Intensity of X-ray Reflection by Diamond,*" was read by Sir W. H. BRAGG.

The paper describes an investigation of the relative intensities of the reflections of monochromatic X-rays by the various crystallographic planes of diamond. The special difficulties due to the small size of available crystals and the modification of the usual method required to obviate them are discussed. An interesting feature of the results is that they lie very closely on smooth curves, which indicates that if the outer electrons of the carbon atom lie at any considerable distance from the centre they must be in motion over a wide range, or for some other reason must contribute little to the reflection.

It is shown that the properties of the carbon atom in diamond are based on a tetrahedral and not a spherical form. The tetrahedra point away from any (111) plane in the case of half the atoms, and towards it in the case of the other half. Consecutive 111 planes are not exactly of the same nature and consequently some slight second order reflection from the tetrahedral plane might be expected. This effect, though slight, has been found.

DISCUSSION.

Dr. ANDRADE asked if surface tension effects entered into the problem

Dr. RAYNER asked if there was any chance of obtaining the arrangement of carbon atoms in the benzene ring.

Prof. BRAGG explained that surface tension effects did not come in. In reply to Dr. Rayner, he exhibited a model of the benzene group.

Exhibit of Photographs by M. le Duc de Broglie.

Prof BRAGG exhibited and explained photographs by M. le Duc de Broglie of the "Magnetic Spectra" obtained when the β-rays produced when X-rays strike copper are deflected on to a photographic plate by a magnetic field.

A paper entitled "*A Method for the Micro-analysis of Gases by the Use of the Pirani Pressure Gauge,*" by the Research Staff of the General Electric Co., Ltd., was read by Dr. N. R. CAMPBELL.

SUMMARY.

(1) A method of analysis of gases at a pressure between 0·61 and 0·001 mm. is described, based on the characteristic vapour-pressure temperature curve of any substance.

(2) The method demands a gauge which will measure the pressures of vapours, as well as of permanent gases, over the range mentioned. The Pirani gauge is suitable for this purpose, especially if it is used in a way which is not new, but of which the advantages have not been sufficiently recognised.

DISCUSSION.

Dr. J. S. G. THOMAS asked if the method would discriminate between the higher hydrocarbons in coal gas, or between ethane and methane. It was assumed that the heat lost by conduction at the ends of the supports was constant. He did not think this was justified, as it had been shown that at low pressures this loss depended on the pressure of the gas. Would the method discriminate between dry and wet gas at the same total pressure?

Dr. D. OWEN expressed his admiration of the method, which appeared to be entirely new. To what pressures had the author gone down to in these experiments? In addition to the Pirani gauge the McLeod gauge is referred to, but no others. Had Dr. Campbell any experience of other forms of low-pressure gauge and their properties?

Dr. CAMPBELL, in reply, said it was easy to analyse any mixture of components which could be frozen out by liquid air. They had analysed the vapours from the oil used in their pumps, and he thought the higher hydrocarbons in coal gas would present no difficulty. He was afraid neither ethane nor methane would freeze out, and so could not be treated by this method. As regards the validity of the assumptions of the heat loss for accurate work every gauge is separately calibrated, and no assumptions are made. The instrument could be used to discriminate between wet and dry gas, provided the total pressure is under 0·2 mm. He did not know how low pressures the Pirani gauge would do for, but for very low pressures the Ionisation gauge would be more accurate

NOTES.

LACQUERS, ENAMELS, VARNISHES.—The manufactures of the New Explosives Company are gaining very great appreciation in all industries. The manufacture of nitrocellulose for industrial purposes has been seriously undertaken by the Company at their Stowmarket factory, and a large number of lacquers and varnishes have been produced. We have had an opportunity of testing several of these productions, and have been particularly interested in the black anti-corrosive enamels, in view of their use in places where heat and noxious fumes are present. The results of tests extending over some months show them to be very valuable; they are easily applied, dry quickly, and keep their surface under conditions where most other paints fail. For "spraying" they are most useful; the dead black particularly gives a fine surface for ironwork that is exposed to acid fumes, such as are met with in the chemical laboratory, while for art ironwork it cannot be surpassed.

TENDERS FOR DISINFECTANTS.—The Ministry of Communications, Belgrade, is inviting tenders to be submitted by June 22 for the supply of the following disinfecting materials: 40,000 kilos. of pink chloride powder (without iron supplements, and without free chlorohydrogen acid); 700,000 kilos. of creosote (with the following specifications—minimum 5 per cent of phenol, cresol, and their "homologues"; it should be liquid at 15° C.). In the offers, which must bear a 10 dinars duty stamp, prices must be stated all charges paid Belgrade or port. They must be enclosed in a sealed envelope, and addressed "Ekonomsk Odelenje, Ministarstva Saobracaja." On the envelope should be written "Ponuda za licitaciju pinkhlorida i creozota." A deposit of 10 per cent by S.C.S. subjects, and 20 per cent by foreigners must be made before or on the date of tendering. It is desirable for United Kingdom firms interested in Serb, Croat, Slovene State contracts to be represented in that kingdom. The Department of Overseas Trade is prepared to assist in the appointment of agents.

BRITISH SCIENCE GUILD. SUB-COMMITTEE ON APPARATUS.—The question of the quality, supply, and prices of British laboratory glassware, porcelain, and chemicals, including research chemicals, is under consideration by a Committee of the British Science Guild. The Committee, the Chairman of which is Sir. Richard Gregory, is anxious, in view of the conflicting statements which have appeared from time to time on these matters, to obtain the views of scientific workers who have experience of recent articles of the kind described, both of British and foreign manufacture. It is obvious that the information can be of use only when it applies to goods of definitely known origin. The points on which information is desired are: the quality of the goods; their price as compared with that of imported articles of the same quality; the facilities for obtaining supplies; and the effects, if any, on research work of restrictions imposed on the importation of German goods. The Committee would also welcome statements made, or reasoned conclusions arrived at, by competent bodies who have investigated these questions recently, and from manufacturers who wish to add any further definite information to that which has already appeared in the Press. The information should be sent to the Secretaries of the Committee, Prof. J. R. Partington, East London College, or Mr. C. L. Bryant, 23, Peterborough Road, Harrow, as soon as possible.

METRIC SYSTEM ADOPTED IN JAPAN.—The new Weight and Measure Law as passed by the Diet was formally promulgated recently by the Japanese Government, thus rendering Japan one of the metric countries. Simultaneously with the promulgation of the new law, Director Kitsukawa, of the Weight and Measure Office, gave out a statement, saying that even when the first weight and measure law was framed in 1893, Japan was desirous of adopting the metric system, but the nation was not ready to accept it, and the old systems were fully adopted. "Several times since, the wholesale reform of the weight and measure

systems has been attempted," the official's statement continues, "but it was quite difficult, before the war, to break with the old systems and adopt the new one to which the nation was but little accustomed. When the world war started, however, the necessity of adopting the metric system was keenly felt, and the Government Bill was readily accepted by the Diet." According to the Yokohama Chamber of Commerce *Journal*, within the five years beginning with the date from which the Law takes effect, all public works, Government offices, schools, and large factories will be made to adopt the new system, while the general public will be given 20 years' grace.

ACTION OF HIGH TEMPERATURES ON PARAFFIN.—Crude Boryslaw petroleum (d. 0·856) was distilled by Messrs. Burstyn and W. Jakubowicz, after treatment with 50 per cent sulpuric acid (98 per cent at 40° C.), followed by washing. Accordingly as distillation is stopped at 150°, 200°, 250°, or 300° C., the proportion of paraffin obtained in the residue is 13·8 per cent, 12·8 per cent, 12·2 per cent, or 10·1 per cent. In any case the solidification point of the paraffin is 51·5° C. As there are not appreciable quantities of paraffin in the distillates, the differences in the amounts obtained are ascribed to the decomposition even at 125° C., due chiefly to the action of the air. For this reason distillation in a vacuum is recommended.—*Matières Grasses*, April 15, 1921.

ITALIAN MERCURY INDUSTRY.—Monte-Amiata in Grosseto Sierra is the centre of the Italian mercury industry, the production of this district, about 1000 metric tons of metal yearly, representing about the total for all Italy. It is estimated that this deposit can supply ore in much the same quantity for several hundreds of years. The ore-producing zone is 40 kilometres long, running parallel to the Apennines, and covering an area of about 400 sq. kilometres. There are eight mines now worked. The ore is usually red sulphide or cinnabar. The high cost of fuel (coal and wood) is the greatest burden in expenses for smelting. Ther are two types of furnaces in use, one for large pieces of ore, which are mixed with wood fuel, simple shaft furnaces, and the other a special type for smaller pieces. There are two causes which considerably affect cost price, viz., emanations of sulphuretted hydrogen, involving employment of powerful electric fans, and the nature of the soil which becomes saturated with water and causes falls of earth in the galleries.—*Génie Civil*, April 9, 1921.

AN International Agricultural and Industrial Exhibition will be held at Riga from July 31 to August 28, 1921. The Exhibition will be under the control of the Lettish Government. Full particulars and information can be obtained from The British and Russian Transport Co., Ltd., 6, Lloyd's Avenue, E.C.3.

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BOOKS RECEIVED.

"The Chemical Effects of Alpha Particles and Electrons." By SAMUEL C. LIND. Pp. 182. New York: The Chemical Catalog. Co.

"A Text-book of Inorganic Chemistry." Edited by J. NEWTON FRIEND. Vol. IX. Part II., "Iron and its Compounds." Pp.xxv +265 illustrated. London: Charles Griffin & Co. Price 18s. net.

"Perfumes, Essential Oils, and Fruit Essences." By GEOFFREY MARTIN. Pp. vii.+138. London: Crosby Lockwood & Sons. Price 12s. 6d net.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

14852—Budd, C. C. L. G.—Manufacture of hydro oxycellulose, a new yanthogenated compound therefrom, etc. May 28th.

14459—Casale, L.—Apparatus for catalytic synthesis of ammonia. May 24th.

Specification published this Week.

16,162—Ellis, G. B.—Purification of ammonia salts.

Abstract Published this Week.

Aluminium Sulphate.—Some further improvements in the process of obtaining Aluminium Sulphate has been Patented No. 161606 by Messrs. Spence & Sons, Ltd., of Alum Works, Holland Street, Manchester. Impure basic aluminium sulphate solutions, obtained by treating ground aluminous material with sulphuric, are freed from iron by agitating with potassium sulphate in the presence of the suspended undissolved material. The invention consists in adding specially prepared finely-divided insoluble matter called "nucleus material" to the substantially clear aluminium sulphate solution containing a potassium salt, before agitating. The insoluble siliceous residue from the treatment of the finely-ground aluminous material with sulphuric acid when re-ground in the wet condition is suitable as nucleus material but finely divided native alunite or other insoluble substances may also be used. It is added in the form of mud either at once or in portions as the purification proceeds. A portion of the separated solids may be used as nucleus material, after further regrinding, in the next operation and valuable constituents are recovered from the remainder, for example by treating with sulphuric acid, preferably after the content of precipitated matter had been raised by repeated use.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK.

Tuesday, June 21.

Mineralogical Society, 5.30.

Thursday, June 23.

Royal Society. "A Study of Catalytic Actions at solid Surfaces," by E. F. Armstrong and T P. Hilditch. "A Contribution to the Thermodynamical Theory of Explosions": Part I; by Sir J. B. Henderson; and Part II (with Prof. H. R. Hassé). "Eddy Current Losses in Cylindrical Conductors with special Applications to the Alternating Current Resistances of short Coils," by S. Butterworth. "On the Currents induced in a Cable by the Passage of a Mass of magnetic Material over it," by E. S. Bieler. "The Experimental Analysis of Sound in Air and Water; some Experiments towards a Sound Spectrum," by Guy Barlow and H. B. Keene. "The Theory of Analysis of an Electric Current by periodic Interruption," by Guy Barlow.

Friday, June 24.

Physical Society, 5.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

SUBSCRIPTIONS, £1 12s. per annum, payable in advance, should be addressed to the MANAGER.

BACK NUMBERS and VOLUMES can be purchased on application to he MANAGER.

THE CHEMICAL NEWS,
97, SHOE LANE, LONDON, E.C 4.

ADVERTISEMENTS.

All communications for this Department should be addressed to—
T. G. SCOTT & SON,
63, LUDGATE HILL, LONDON, E.C.4.

UNIVERSITY OF GLASGOW.

APPLICATIONS are invited for a Lectureship in Organic Chemistry; salary £400 to £450 according to qualifications. Applications, stating teaching and research experience and giving the names of three references, to be sent as soon as possible to Prof. T. S. PATTERSON. Any available copies of testimonials may also be sent.

CITY OF BIRMINGHAM EDUCATION COMMITTEE.

HANDSWORTH TECHNICAL SCHOOL.

REQUIRED in September next, the full-time services of a Lecturer, chief subject Metallurgy. The commencing salary offered wi l depend upon the previous training and experience of candidate. For full particulars apply to the Principal, Handsworth Technical School, Goldshill Road, Handsworth, Birmingham.

STAFFORDSHIRE EDUCATION COMMITTEE.

APPLICATIONS are invited for the post of PRINCIPAL and HEAD of the METALLURGICAL DEPARTMENT of the COUNTY TECHNICAL COLLEGE, WEDNESBURY, (in succession to Mr. Walter Macfarlane, F.I.C.), at a salary of £600. The person appointed must be a competent metallurgist with good academic qualifications; practical experience in works is essential.

Further particulars and forms of application, which must be returned before 8th July, may be obtained from the undersigned.

GRAHAM BALFOUR,
Director of Education.

County Education Offices,
Stafford.
June, 1921.

THE owners of British Patent No. 14004/14 entitled "IMPROVEMENTS RELATING TO EXPLOSIVES" desire to dispose of the Patent and would be willing to enter into working arrangements under license with a firm likely to be interested, or would sell the Patent outright.

A copy of the specification and full particulars may be obtained from
HERTFORD RECORD CO., Ltd., of LINDSEY HOUSE,
59, LINCOLN'S INN FIELDS, LONDON, W.C.2.

TRAY DRYERS and TROUGH DRYERS: —Thos. G. Marlow, Drying Consultant & Desiccation Expert, Drying Laboratories, OLDRIDGE ROAD, LONDON, S.W.12.

PATENTS, TRADE MARKS. Handbook and advice free—B. T. KING, British and U. S. Regd. Patent Attorney, 146a, Queen Victoria St., London. 35 years reference

THE CHEMICAL NEWS.
VOL. CXXII., No. 3193.

EDITORIAL.

AFTER much discussion and enquiry it has been decided to make an alteration in the appearance and also the title and contents of the CHEMICAL NEWS.

The needs of the advertisers have called for a better surfaced paper for the cover, and it has been thought that a distinctive colour will be more satisfactory than the present one, which has remained unchanged since the first issue in 1859.

The great advances that have, within the last 25 years, been made in the domains both of chemistry and physics, and the fact that these advances have been largely absorbed in our national industries has brought the CHEMICAL NEWS into the hands of manufacturers and merchants to a very much greater extent than in the past.

We are, therefore, venturing to alter the latter part of the title to "Journal of Industrial Science" and to make an appropriate alteration to the title-page of the volume.

These are matters of small moment. What is of more importance is that we propose for the future to make the first issue in each month four pages larger than heretofore, and to devote the four additional pages to the notice of the very numerous new books that are now appearing, dealing with chemical and physical science.

Firmly believing that we shall before long enter upon a period when the present state of unrest and agitation will give place to one of serious work and production, it is our intention to lose no time in contributing our mite to the increasing activity in industrial science. We shall greatly value any suggestions and criticisms upon the course we are taking.

The last Friday Evening Lecture of the Session at the Royal Institution was delivered by Sir J. J. Thomson, O.M., on the "Constitution of the Atom." The subject is one of fascinating interest, and will probably mark an epoch in our accepted ideas of the physical nature of atomic matter. It was pointed out that the recent discoveries of radioactivity had brought the chemist and physicist into very close relation, to their mutual advantage; certainly the old idea of a solid individual particle has gone, and in its place we have an atom of positive electricity surrounded by a more or less complicated system of negative electrons. This idea, originating in the investigations of Sir Ernest Rutherford, Prof. Soddy, and others, has been elaborated by Sir Joseph Thomson, and now stands upon an unassailable foundation. By means of a series of ingenious models and diagrams, the details of the new system were explained, and many of the well-known chemical reactions were made clear.

At the conclusion of the lecture the opportunity was taken to make a presentation to Sir James and Lady Dewar on the occasion of their golden wedding. The gift of the members of the Royal Institution took the form of a very beautifully figured gold vase, and was presented by His Grace The Duke of Northumberland, who briefly reviewed the work of Sir James Dewar, and dwelt upon its world-wide value and importance.

Sir James Dewar, who was visibly affected by the occasion, acknowledged the gift on the part of Lady Dewar and himself, and gave a short history of his long connection with the Institution, and of the vicissitudes through which it had passed.

To the writer, whose acquaintance with the Royal Institution has been of very many years standing, the occasion was one of deep interest. Every detail of the work of Sir James Dewar from the far-away days when the vacuum vessel was a square-sided box of glass, past the early days of the compression of oxygen in brass pumps, through the brilliant researches and the glorious experiments that recorded the liquefaction of air, nitrogen, oxygen, and the inert gases of the atmosphere, passed through the mind in luminous succession, together with the faces of many who at one time seemed to be part of the Institution—now, alas! alive only in remembrance. One or two only are left, and the most prominent of these was Sir James, who occupied the same seat that he always holds (it is unthinkable to imagine him in any other part of the theatre), and it was a real pleasure to hear him speak of continued vigour and hope of further activity: a hope that we heartily endorse.

POLYMERISATION AMONGST LIQUIDS.

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IN a previous article (CHEMICAL NEWS, vol. cxxii., No. 3170), I calculated the degree of polymerisation (p) for a number of elements and compounds in the solid state. In the present article I propose to find the relative sizes of the aggregations of certain substances at their boiling-points, and then to calculate p for a number of typical liquids.

Assuming the truth of

$$p_x = \frac{k}{W_x S_x}$$

I first made a comparison between the rates of polymerisation of certain liquids at 302° A. For bromine, if W=80, s=0·1071, and p=1, then k=8·57. The results are given in Table I.

TABLE I.

Substance	W	S.	Relative value of p	Minimum value of p
Br ...	80	0·1071	1	1·37
H_2O ...	6	1	1·43	1·96
P (yellow)	31	0·2045 at 346°		
		$<$0·2045 – F.P.	$>$1·35	$>$1·85
Pb ...	207	0·047 – 653°		
		$<$0·047 – F.P.	$>$0·88	$>$1·20
Hg ...	200	0·0333	1·3	1·78
Cl ...	35·5	0·223 – 240°		
		$>$0·223 – 302°	$<$1·07	$<$1·46
Ga ...	69·9	0·0802 – 392		
		$<$0·0802 – F.P.	$>$1·52	$>$2·08
Al ...	27	0·3914 – 947°		
		$<$0·39 – F.P.	$>$0·816	$>$1·12
Cu ..	63·5	0·1556 – 1357°		
		$<$0·1556 – F.P.	$>$0·87	$>$1·2
Ag ...	108	0·0748 – 1276°		
		$<$0·0748 – F.P.	$>$1·06	$>$1·45

Bi ...	208	0·0363–603°		
		<0·0363–F.P.	>1·13	>1·55
Zn ...	65·4	0·1786–732°		
		<0·1786–F.P.	>0·73	>1
Sn ...	119	0·0637–513°		
		<0·0637–F.P.	>1·13	>1·55
AgCl	71·7	0·129 –767°		
		<0·129 –F.P.	>0·92	>1·26
AgBr	94	0·076 –769°		
		<0·076 –F.P.	>1·2	>1·64
$PbBr_2$	122	0·078 –811°		
		<0·078 –F.P.	>0·9	>1·23
PbI_2	154	0·0645–648°		
		<0·0645–F.P.	>0·86	>1·18
$LiNO_3$	23	0·390 –549°		
		<0·390 –F.P.	>0·95	>1·3
$NaNO_3$	17	0·430 –623°		
		<0·430 –F.P.	>1·17	>1·6
KNO_3	20	0·333 –633°		
		<0·333 –F.P.	>1·28	>1·75
$AgNO_3$	34	0·187 –518°		
		<0·187 –F.P.	>1·35	>1·85
$KClO_3$	24·5	0·325 –550°		
		<0·325 –F.P.	>1·07	>1·46
C_2H_5OH	9·1	0·648	2·6	3·56

Raising the least value of p (*i.e.*, 0·73 for zinc) to 1, we obtain the minimum values at 302° A. (last column). Even these values may not be high enough, for p for *every* liquid must be at least 1 at the boiling-point.

In Table II. I have compared the values of p in the solid and liquid states.

TABLE II.

Substance	Solid. p	Solid. Temp.	Liquid. p	Liquid. Temp.
Cl	1·5	172°	1·37	240°
Br	1·5	266°	1·37	302°
P	1·53	298°	>1·85	F.P.
Bi	1·51	307°	>1·55	,,
Sn	1·5	323°	>1·55	,,
Pb	1·47	307°	>1·20	,,
Al	1·72	300°	>1·12	,,
Ga	1·71	291°	>2·08	,,
Zn	1·58	306°	>1	,,
Hg	1·45	214°	1·78	,,
Cu	1·67	330°	>1·2	,,
Ag	1·62	400°	>1·45	,,
AgCl ...	1·48	330°	>1·26	,,
$AgNO_3$ ...	2·00	330°	>1·85	,
$NaNO_3$ ...	2·15	316°	>1·6	,,
KNO_3 ...	2·04	303°	>1·75	,,
$KClO_3$ ...	2·01	307°	>1·46	,,
H_2O	3	273°	1·96	,,

There are at least five elements in this list which are more highly polymerised (at the melting-point) in the liquid than in the solid state, viz., phosphorus, bismuth, gallium, mercury, and tin. (If data were available probably there would prove to be many more). Now mercury and phosphorus contract on freezing; so do copper, lead, tin, silver, &c.; whereas bismuth expands on freezing, like water (see Roberts-Austen: "Introduction to the Study of Metallurgy," 5th edition, p. 16). Hence the difficulty of explaining the phenomenon. It is probable that solid phosphorus consists of monatomic and diatomic molecules, and when liquefaction takes place, some of the phosphorus molecules associate to form P_2, P_4, &c., molecules. The same explanation might apply to bismuth, gallium, mercury, &c. (see further reference to this subject after Table VI.).

As I wished to compare the degree of polymerisation of different groups of compounds between 200-400° A., I tried to select two elements which are liquid within these limits, in the same group of the Periodic Table, if possible, so that I could assume with some justification that they acted somewhat similarly, *i.e.*, either aggregated or polymerised to the same extent at corresponding temperatures.

Assuming $p=1·37$ for bromine at 302° A., then it is <1·46 for chlorine at 302° A., but >< 1·46, *i.e.*, about 1·37 at 240° A. I made the bromine aggregation at 302°=2, *i.e.*, its vapicular weight is 160. Then,

$$\frac{T \times p \times s \text{ (observed)}}{R_T} = k$$

Substituting 302° A. for T,
1·37 for p,
0·1071 for s at 302°,
2 for R_T ——,
then $k=22·15$.

For chlorine (at 240° A.) $R_T=3·31$, and its vapicular weight=118. Thus,

	Cl	Br
T	240	302
Vap. wt.	118	160

By inter- and extra-polation the vapicular weights corresponding to all temperatures quoted in this paper can readily be obtained (1° rise or fall in temperature=0·68 in V. wt.). Or a formula, similar to that used for solids, connecting vapicular weights and temperature, can be obtained as follows:—

$$\frac{240-x}{\sqrt{118}} = \frac{302-x}{\sqrt{160}}$$

$$x = -136$$

$$\therefore \frac{T+136}{\sqrt{\text{Vap. wt.}}} = k$$

From data for chlorine,

$$\frac{240+136}{10·86} = k = 34·62$$

$$\therefore \frac{T+136}{34·62} = \sqrt{\text{Vapicular weight}}$$

The results for water are given in Table III. The specific heats used are those obtained by Callender and Barnes (quoted in Edser's Heat). There are several tables given in Landolt-Börnstein, "Physikalisch-Chemische Tabellen," but they are all slightly different from each other, agreeing only in one respect, that the minimum specific heat is between 293° and 313° A.

TABLE III.

Absolute Temp.		S_T	S_{obs}	p
273 (ice)	(R=69)	—	—	3
273	(R_1=23·3)	1·8904	1·0054	1·88
283		1·9175	1·0022	1·91
293		1·93	1·0000	1·93
303		1·9591	0·9987	1·96
313		1·9673	0·9982	1·97
323		1·9887	0·9987	1·99
333		2·0090	1·0000	2·01
348		2·0240	1·0024	2·02
363		2·0441	1·0053	2·03
373		2·0606	1·0074	2·04

Thus, throughout the liquid state there is a slight rise in the value of p. On melting, apparently, some of the trihydrol breaks up into dihydrol and monhydrol. Consider 100 molecules of trihydrol. Let x persist when the ice melts, the remaining $(100-x)$ molecules breaking up into $(100-x)$ molecules of dihydrol, and $(100-x)$ molecules of monhydrol. There are now $(200-x)$ molecules of tri-, di-, and monhydrol present, whose average degree of polymerisation is 1·88.

$$\therefore\ 1{\cdot}88\ (200-x)=100\times 3$$
$$\therefore\ x=40{\cdot}4$$

Thus, 59·6 per cent of the trihydrol breaks up when ice is melted, and of the new molecules formed 40·4 are $(H_2O)_3$, 59·6 are $(H_2O)_2$, and 59·6 are (H_2O). That is, there is an increase in the number of molecules, yet a decided diminution in volume. Thus, at 273° A., water contains 40·4 per cent by ***weight*** of trihydrol, and ***by number*** 25·3 per cent of $(H_2O)_3$, 37·3 per cent of $(H_2O)_2$, and 37·3 per cent of H_2O.

This is assuming that none of the monhydrol molecules associate amongst themselves to form dihydrol. Supposing all the monhydrol becomes dihydrol, then the equation becomes

$$1{\cdot}88\left[\frac{300-x}{2}\right]=300,$$

which gives a negative value for x. From Table III. it will be obvious that the monhydrol molecules could not all be transformed into dihydrol until above 330° A. (when $p=2+$) although a certain proportion may do so at any temperature between 273° and 373° A. That something like this is occurring is evident from the irregular specific heats, and from the fact that the point of maximum density can be lowered by increasing the pressure, when p would be altered too.

The three kinds of molecules exist side by side, in varying amounts, until boiling-point, when liquid water is about two-thirds dihydrol (see Table IV.). At the conversion of 100 molcules of trihydrol (ice at 273° A.) into 159 mixed molecules at the same temperature, there is a decided shrinkage in volume, showing that trihydrol has a big configuration, and monhydrol a small one, the dihydrol coming in between. Under increased pressure, ice (at 273° A.) liquefies, its volume is reduced, and presumably the bulky trihydrol configurations are broken down, thereby reducing the value of p. The relation between pressure and p will be dealt with later.

The specific heat of trihydrol (ice at 273° A.) $= \dfrac{9}{6\times 3}=0{\cdot}504$.

The specific heat of dihydrol $=\dfrac{11{\cdot}34}{W\times p}=0{\cdot}945$ (at 273° A.).

The specific heat of monhydrol $=\dfrac{11{\cdot}34}{W\times p}=1{\cdot}890$ (at 273° A.).

I have calculated the relative sizes of these three molecules as follows: I have assumed that the size of the dihydrol molecule is the arithmetical mean of the other two.

Let size of trihydrol molecule be 2; then size of dihydrol molecule is $1+x$; and size of monhydrol molecule is $2x$. 11 cc. of ice at 273 become 10 cc. of water at the same temperature. Therefore, starting with 100 molecules of trihydrol,

$$100\times 2=\tfrac{11}{10}\left\{(40{\cdot}4\times 2)+59{\cdot}6(1+x)+59{\cdot}6(2x)\right\}$$
$$=\tfrac{11}{10}(80{\cdot}8+59{\cdot}6+59{\cdot}6x+119{\cdot}2x)$$
$$=\tfrac{11}{10}(140{\cdot}4+178{\cdot}8x)$$
$$\therefore\ x=0{\cdot}231$$
$$\therefore\ 2x=0{\cdot}462$$
$$\therefore\ 1+x=1{\cdot}231$$

The relative volumes are :—

$$\left.\begin{matrix}(H_2O)_3 & 2\\ (H_2O)_2 & 1{\cdot}231\\ (H_2O) & 0{\cdot}462\end{matrix}\right\}\ \text{or}\ \left.\begin{matrix}4{\cdot}33+\\ 2{\cdot}66+\\ 1\end{matrix}\right\}.$$

Their relative densities can be obtained as follows :—

	Relative number at 273° A	Relative Vols.	Relative Weights	Relative Densities
$(H_2O)_3$	40·4	2	3	1·5
$(H_2O)_2$	59·6	1·231	2	1·624
(H_2O)	59·6	0·462	1	2·164

Total volume $=140{\cdot}4+178{\cdot}8\ x$ (where $x=0{\cdot}231$)
$=181{\cdot}7$

Total weight $=300$

$$\therefore\ \text{Density}=\frac{300}{181{\cdot}7}=1{\cdot}651$$

The actual density of water at 273° A. is 1, so that the densities of $(H_2O)_3$, $(H_2O)_2$, and (H_2O) are 0·908, 0·983, and 1·310 respectively.

What happens to water at 4° C.?

Let m additional molecules of trihydrol break up between 273° and 277° A., and further, assume that none of the monhydrol is transformed into dihydrol. The water formed at 273° has a volume of $140{\cdot}4+178{\cdot}8x=181{\cdot}7$.

The volume at 277° A. (4° C.) will be

$$2(40{\cdot}4-m)+1{\cdot}231(59{\cdot}6+m)+0{\cdot}462(59{\cdot}6+m)$$
$$=(80{\cdot}8-2m)+(73{\cdot}4+1{\cdot}231m)+(27{\cdot}5+0{\cdot}462m)$$
$$=181{\cdot}7-0{\cdot}307m.$$

$$\frac{\text{The volume at }273^\circ}{\text{The volume at }277^\circ}=1{\cdot}00013$$

$$\therefore\ \frac{181{\cdot}7}{181{\cdot}7-0{\cdot}307m}=1{\cdot}00013$$

$$\therefore\ 0{\cdot}30704m=0{\cdot}0236$$

$$\therefore\ m=<0{\cdot}08$$

That is, only a very small quantity of trihydrol breaks up between 273–277°, and we can regard the point of maximum density as the close of the $(H_2O)_3 \rightarrow (H_2O)_2+H_2O$ action, or the completion of the melting process.

After 277° A. both

$$2(H_2O)_3 \rightarrow 3(H_2O)_2 \text{ and}$$
$$2(H_2O) \rightarrow (H_2O)_2$$

are proceeding, and a rough calculation of their relative importance can be made as follows. From 277-373° there is an expansion. Now $2(H_2O)_3 \rightarrow 3(H_2O)_2$ represents a contraction from (2×2) to $3(1{\cdot}231)=0{\cdot}307$; and $2(H_2O) \rightarrow (H_2O)_2$ an expansion from $(2\times 0{\cdot}462)$ to $1{\cdot}231=0{\cdot}307$.

If both actions proceeded together at the same rate there would be no change in volume, so that the second one, viz., $2H_2O \rightarrow (H_2O)_2$ must be proceeding more rapidly than the former one.

At 277° the composition of water is practically the same as at 273° A., viz., 40·4 molecules of $(H_2O)_3$, 59·6 molecules of $(H_2O)_2$, and 59·6 molecules of (H_2O).

The 59·6 molecules of $(H_2O)_2$ will not undergo any further change; but between 277-373° A. let x trihydrol molecules pass into $xH_2O + x(H_2O)_2$

y trihydrol molecules pass into $\frac{3y}{2}(H_2O)_2$

z monhydrol molecules pass into $\frac{z}{2}(H_2O)_2$

The net increase in volume due to these actions is

$$-x(2-1{\cdot}231-0{\cdot}462)+y(2-1{\cdot}846)+\frac{z}{2}(0{\cdot}615-0{\cdot}462)$$

$$=-0{\cdot}307x+0{\cdot}154y+0{\cdot}153z.$$

The volume at 277° is 181·7 and as the average coefficient of expansion of water is 0·00045 the volume is increased between 277–373° A. by 7·85.

$$\therefore \quad -0{\cdot}307x+0{\cdot}154y+0{\cdot}153z=7{\cdot}85$$

$$i.e., \; -2x+y+z=51{\cdot}3$$

No likely results are obtained by giving any value to x, *i.e.*, the action $(H_2O)_3 \rightarrow (H_2O)_2 + H_2O$ ends at 277° (under atmospheric pressure); unless it follows the course.

$$2(H_2O)_3 \rightarrow 2(H_2O)_2+2H_2O$$
$$\rightarrow 2(H_2O)_2+(H_2O)_2$$
$$\rightarrow 3(H_2O)_2$$

Suitable values for y and z can be found so that p at 373° will be 2·04. This condition is satisfied when $x=0$, $y=13$, and $z=38{\cdot}3$. Water at 373° consists, then, of

$(H_2O)_3$ 27·4
$(H_2O)_2$ 98·3
(H_2O) 21·3

These results are summed up in Table IV.

TABLE IV.

		$(H_2O)_3$	$(H_2O)_2$	(H_2O)
Specific heat (273°)		0·5	0·945	1·890
Relative volume		2	1·231	0·462
		4·33	2·66	1
Density		0·908	0·983	1 310
Percentage comp. of water				
273°	By weight	40·4	39·7	19·9
	By number	25·3	37·3	37·3
373°	By weight	27·4	65·5	7·1
	By number	18·6	66·8	14·5

As the observed specific heats and the degrees of association of water are practically constant, compared with many other liquids, the product of p and s is almost constant between 273-373° A., ranging from 1·89 to 2·06. In finding the "molecular weight" (*i.e.*, the polymericular weight) of a liquid (x) at 273° A.,

$$p_x^{273} = \frac{k}{W_x S_x}$$

For water, $p=1{\cdot}88$

$s=1{\cdot}0054$

$w=6$

$\therefore \; k=11{\cdot}34$

$$\therefore \; p_x^{273} = \frac{11{\cdot}34}{W_x S_x}$$

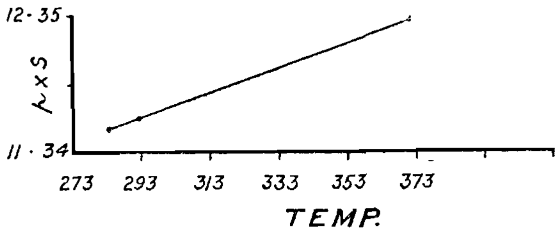
$$\text{and} \quad p_x^{373} = \frac{12{\cdot}36}{W_x S_x}$$

The values of k at other temperatures can be obtained from Table V. or Fig. 1.

TABLE V.

Absol. Temp.	$p \times s$ (*See* ST, Table III).	R	Absol. Temp.	$p \times s$	R
273°	1·89	11·34	323°	1·99	11·94
283°	1·92	11·52	333°	2·01	12·06
293°	1·93	11·58	348°	2·02	12·12
303°	1·96	11·76	363°	2·04	12·24
313°	1·97	11·82	373°	2·06	12·36

FIG. I.

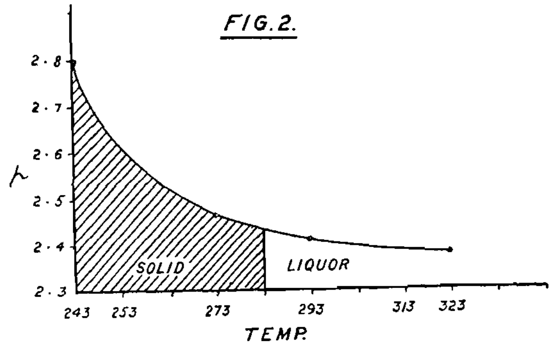


The specific heats of a few liquid inorganic compounds have been determined, and from them their degrees of polymerisation have been calculated. See Table VI.

TABLE VI.

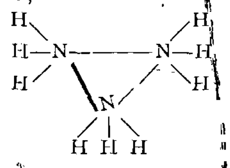
Compound	Absol. Temp.	Liquid. ST.	$S_{obs.}$	p	Solid. p	Temp
AgCl	767	0·191	0·129	1·48	1·48	330
AgBr	769	0·146	0·076	1·92	—	—
TlCl	751	0·115	0·059	1·95	—	—
$PbCl_2$ ...	811	0·148	0·121	1·22	1·59	333
$PbBr_2$ ...	811	0·113	0·078	1·45	—	—
PbI_2	646	0·0877	0·0645	1·36	—	—
$LiNO_3$ ...	549	0·958	0·390	2·45	—	—
$NaNO_3$ ...	623	0·672	0·430	1·56	2·07	329
KNO_3 ...	733	0·677	0·333	2·03	2·03	329
$AgNO_3$ ...	518	0·385	0·187	2·06	2·00	330
$K_2Cr_2O_7$ ..	713	0·509	0·335	1·52	1·92	309
$KClO_3$ ...	550	0·538	0·325	1·66	2·01	307
H_2SO_4 (solid)	243	—	—	—	2·80	243
H_2SO_4 (solid)	273	—	—	—	2·48	273
H_2SO_4 (liquid)	293	0·8315	0·3447	2·41	—	—
H_2SO_4 (liquid)	323	0·8524	0·3585	2·38	—	—
SO_2 (solid) ...	127	—	—	—	1·81	127
SO_2 (liquid)	253	0·516	0·313	1·65	—	—
SO_2 (liquid)	273	0·532	0·317	1·67	—	—
$Na_2S_2O_3.5H_2O$	329	1·064	0·569	1·86	—	—
$Na_2HPO_4.12H_2O$	343	1·492	0·758	1·96	—	—
$CaCl_2.6H_2O$	340	1·159	0·552	2·10	—	—
NH_3 (solid)	85	1·858	0·5	—	3·72	85
NH_3 (liquid)	273	2·678	0·876	3·05	—	—

The results in Table VI. are not only interesting but perplexing. We should expect that p would be less in the liquid than in the solid state. Taking ice at 273° as trihydrol, p for AgCl., KNO_3, $AgNO_3$, &c., is practically the same at the M.P. in both the liquid and solid states; so is it for H_2SO_4 and SO_2. The polymerisation curve for H_2SO_4, &c., is practically continuous on change of state (see Fig. II.). There is a fall in

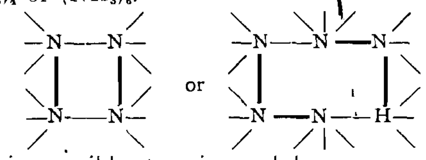


the value of p on melting for $K_2Cr_2O_7$, $KClO_3$, H_2O, &c.; but a rise in the cases of P, Bi, Ga, Hg, $LiNO_3$(?), AgBr, &c. To make p always greater in the solid state than in the liquid state we should have to assume that ice at 273° was $(H_2O)_4$, or more complex still, for all the values of p (in the solid state) are based on $(H_2O)_3$ at 273° (ice).

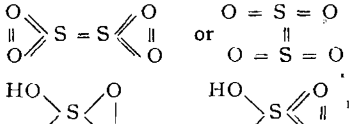
When p is greater in the liquid than in the solid state I should imagine it is for the same reason that p for water is greater at 373° than at 273° A. So, solid phosphorus (P_1 and P_2) on melting becomes more associated still, *i.e.*, P_2, P_4, P_8, &c. In the liquid state p for NH_3 is probably 3, so that N is pentavalent;

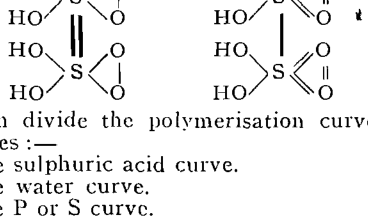


in the solid state ammonia also contains either $(NH_3)_4$ or $(NH_3)_6$.



It is possible to give sulphur a very high valency in both liquid SO_2 and H_2SO_4. Thus:—



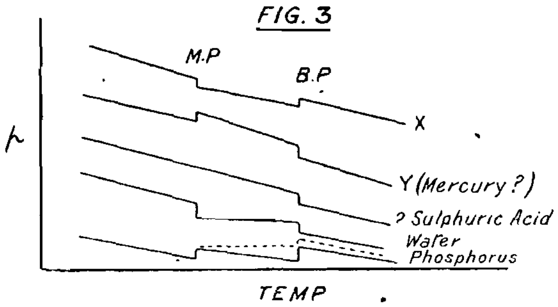


We can divide the polymerisation curves into five classes:—

1. The sulphuric acid curve.
2. The water curve.
3. The P or S curve.
4. X } See Fig. III.
5. Y }

The sulphuric acid curve shows a gradual and continuous fall in the value of p until the boiling point, when p becomes less than 1 (*i.e.*, counting H_2O, SO_3 as half molecules. p for these separate parts is 1+).

The water curve shows a distinct fall in the value of p at the M.P., and again at the B.P. The P curve shows a rise probably at the B.P. as well as the M.P. X and Y are two theoretical curves.



(To be continued).

OSMOTIC PHENOMENA.*

By CHARLES A. SHULL,
The University of Kentucky, U.S.A.

A THOUGHTFUL consideration of the various relationships which exist between plants and their environment, leads one to the conclusion that none is of gerater importance than the relationship established with the moisture of the soil through the roots and root hair mechanism. The fundamental character of this relation is seen clearly in the facts that soil moisture is the dominant edaphic factor in the geographic distribution of vegetation, and that some of the most striking modifications in the form and structure of plants are produced by physical or physiological dryness of the environment. The deserts of the earth have a sparse vegetation not because of infertility, but from low soil moisture content. And the succulent types of plants found in xerophytic and halophytic habitats have been developed through the physiological conditions set up inside the plant incident to low availability of water.

As has been shown recently by MacDougal and others, the course of carbohydrate metabolism is determined in certain succulents by the amount of water existing in the cells, and the probability is that most succulent plants have been modified by the osmotic conditions in their cells. Whenever the water content exceeds the critical amount, the carbohydrates form polysaccharides of low imbibitional capacity. But if the saturation deficit becomes great enough, the tendency is for the carbohydrates to go over into pentosans which are hydrophilous. In such cases ,if in addition there is the production of much free acid during the carbohydrate transformations, succulence will probably result from the combination of circumstances. Thus low availability of soil moisture may fundamentally change the metabolism of the plant, and modify its whole form and structure.

Whether we consider the influence of the plant upon soil moisture, or *vice versa*, the influence of the quantity of soil moisture upon the plant, these influences must act through the same mechanism,

*A Contribution to a General Discussion on "Physico-Chemical Problems Relating to the Soil" held by the Faraday Society, on Tuesday, May 31, 1921.

the osmotically active membranes of the plant. Usually these are living membranes, but osmotic membranes of cellulose, and dead cells, as in seed coats, are now well known.

When dry seeds with osmotically active coats are placed in moist soil, they absorb moisture with great power, such forces an imbibition, capillarity, surface force, hydration power of colloids, and osmotic pressure from internal salts being involved. The total power of the seed to absorb water is the resultant of all these forces working together. Opposed to these internal forces are external forces which tend to prevent intake of water. The surface forces of soils, capillarity, surface tension, adhesion, cohesion of water in thin films, osmotic action of solutes, &c., are pitted against these internal forces; and water movement into or out of the seed will take place in accordance with the lack of equilibrium between the two resultant forces. It is an interesting fact that seeds will actually germinate in a soil that has a moisture content below its wilting coefficient.

As soon as the seed begins to germinate, the characteristic osmotic mechanism for soil water intake is established. The view point is general that the intake of water, its transfer through the plant body, and its distribution to the living cells, are processes involving osmotic action at various places in the organism. Although some suggestions have been made assigning to the root a rather passive rôle in water intake, it seems to me a mistake to adopt the idea that the root is mainly an anchorage organ, and that water merely filters through the root under the negative pressure of atmospheric evaporation and the cohesion of water. The osmotic delivery of water by the root to the lower end of the cohesive water columns probably goes on at a rate determined by all of the physical and chemical conditions within the soil-root system, including the cohesive pull upon the root cells. And if this does not keep pace with evaporation, the deficit in the aerial portions becomes greater and greater, and the tension stronger, until breakage of the column and permanent wilting ensues.

There is reason for believing that the drying power of the atmosphere, which fluctuates greatly with changes in relative humidity, averages not far from 1000 atmospheres. And this is the tremendous force which is responsible for the disturbance of moisture equilibrium in the leaves, generating in the cell walls bounding intercellular spaces, in the protoplasm itself, and in the vacuoles of leaf cells, those imbibitional and osmotic forces which lift the water column of the transpiration stream to the tops of even the tallest plants.

The root hair itself is very well adapted to its function as an absorbing organ. As Miss Roberts has shown, the wall of the root hair is usually the outgrowth of the middle lamella of the epidermal cell. It is lined inside by a cellulose layer deposited upon it by the living protoplasm. The external layer, therefore, is largely calcium pectate, and a pectin mucilage brings it into almost intimate contact with the particles of soil minerals. As this pectic material is a hydrophilous colloid, it is highly adapted to imbibe surface moisture from the particles of soil with which it is in contact. It is worth while to note in passing that the whole problem of water intake and water outgo from the plant begins and ends in imbibition, imbibition of water from the protoplasm and vacuole by the exposed cell walls in leaf interspaces, and imbibition of water from the surface of soil particles by the pectic walls of absorbing root hairs.

There are several main problems connected with the osmotic phenomena of plant life which are worthy of consideration. These are, the nature of osmotic pressure itself, the cause of semipermeability in membranes, and the cause of unilateral movement of water across the semipermeable septum. Before considering the nature of osmotic pressure, the power of the plant to adjust itself osmotically to its environment should be mentioned. It has been fully established by the work of Hill, Drabble, and Drabble, and Miss Roberts, that the plant increases or decreases the osmotic concentration of its cell sap *pari passu* with changes in the environment which determine the scarcity or availability of water for the plant. Miss Roberts' work is especially significant as related to soil moisture, since she made her determinations on root-hair producing cells. She found that the osmotic pressure of the root hairs is maintained a few atmospheres in excess of that of the surrounding medium. Such changes in the root cells are accompanied by corresponding changes in the osmotic mechanism more or less throughout the entire plant, so that appropriate osmotic gradients are constantly maintained. With plants growing in the soil, a similar gradient for moisture intake exists. At the wilting coefficient the soil withholds water from the plant with a force of about four atmospheres, while the usual osmotic concentration of the sap of root cells of land plants is seven or eight atmospheres. In desert regions, of course, these pressures would run much higher. Under normal field conditions, therefore, the pressure gradient in ordinary mesophytic plants should run from four to eight atmospheres, as the fluctuation of the water withholding power is from zero to four atmospheres. At the wilting coefficient the effectiveness of the intake gradient is lost because the rate of transfer of moisture from soil particle to soil particle toward the plant becomes entirely inadequate. And now, even though the plant's osmotic pressure rises rapidly, it does not succeed in securing the needed moisture, because it is trying, as it were, to draw water from a dry well. Permanent wilting must quickly ensue in most cases after the soil reaches the wilting coefficient.

The main criticism to be made of the current discussions of the nature of osmotic pressure is that they attempt to simplify too much a process that must, like other life processes, be complex. We may attribute osmotic pressure to the difference in free energy of the solvent and solution, or to the kinetic energy of the solute acting on the semipermeable membrane. It seems to me more appropriate to consider osmotic pressure a complex force, the resultant of numerous factors. The free energy of the solvent, the kinetic energy of the solute, the chemical forces of hydration, especially in more concentrated solutions, and the attraction of ions in solution for particles of water charged oppositely while passing through the differential septum, are all factors in producing osmotic pressure. In the plant this complex force

is smallest in the root hairs, and progressively increases to the farthest limits of water transfer.

The most important problems in connection with osmosis centre in the nature and causes of semipermeability in membranes. The sieve theory, the various solubility theories, the surface tension theory, and the hydrone theory are all well known. Every one of them has some supporting evidence, but all of them have their limitations, and prove inadequate to account for the known facts.

Armstrong's hydrone theory has come particularly to my attention in connection with my own work. The assumptions which are made in this theory as to the character of semipermeable membranes and the salts which they eclude from passage are of such a nature that they seem to me to necessitate the fundamental likeness in behaviour of all semipermeable membranes. If only hydronated membranes can exhibit semipermeability, and if hydronated membranes exclude all hydronated or hydrolated salts, then all membranes of this kind should have identical behaviour. The variability in behaviour of the natural semipermeable membranes, then, is a challenge to the hydrone theory.

Again, it is not possible to attribute semipermeability to some particular chemical substance in the membrane, like tannin, or suberin, or cutin, &c. Many different kinds of membranes are semipermeable, and no single substance, or class of substances, is common to them all. When copper ferrocyanide and other chemical precipitates, cellulose cell walls, or suberised cellulose, gelatin tannate, celloidin, cutinised tissue, parchment paper, and living protoplasm all exhibit semipermeability, it is certain that this peculiar property does not depend on chemical composition, but must be related rather to the structure of the membrane.

There is one property which all of these membranes have in common. They are all colloidal gels. It is my opinion that any theory of semipermeability should frankly recognise this property, and be couched in the language of the physics and chemistry of colloidal matter.

Water can undoubtedly penetrate both phases of the colloidal gel; but salt molecules attempting to penetrate the membrane would probably be prevented from travelling through the disperse phase by surface tension and other surface forces on the contact surfaces between the disperse and continuous phases. If so, they would have to travel in the contiuous phase.

Recently Free has proposed a theory of protoplasmic permeability based upon this conception. He assumes that protoplasm is made up as a two-phase system in which the phases differ mainly in their percentage of water content, arranged as colloidal globules dispersed in a colloidal medium. These two phases are supposed to be so related that interchange of water between the two can occur accordingly as changes in the physics or chemistry of metabolism, or of the environment, necessitate. By such changes, the colloidal globules may increase in size while the continuous phase decreases; or, *vice versa*, the globules may become smaller while the continuous phase separating them increases in thickness at their expense. Conceivably the globules might reach such a size that the continuous phase would remain as the thinnest possible films between them, or they might enlarge until the gel is reversed, the discontinuous phase becoming a continuous medium, and the former continuous phase becoming discontinuous.

Changes in permeability and semipermeability would be related to these phase interchanges. Semipermeability would exist when the continuous phase existed in such thin films that molecular diffusion through it was impossible. Adequate provision is found here for natural differences in membranes, for they could hardly have identical behaviour unless the colloidal material were identical in kind. Two different kinds of membranes could exhibit differences in reaction toward the same solution, and one would not expect to find semipermeability behaviour identical in all membranes.

It seems clear to me that we must have a theory of semipermeability that recognises the nature of the membrane as Free's theory does. Living protoplasm is an amphoteric substance with an isoelectric point; and it may react as an acid or base depending on hydrogen ion concentration. As it is played upon by various solutes, or by temperature, or light, changes in the permeability or semipermeability relations would undoubtedly occur according to the nature of the solutes, and the effects of other factors on the aggregation in the colloidal system. In non-living membranes like seed coats, the gels are much firmer, more difficult to change, and the characters more stable than in living protoplasm. But even here one might expect changes from permeability toward semipermeability, or *vice versa*, with reagents having powerful effects on colloidal aggregation. In the problem of soil-moisture intake by roots, of course, we are dealing with a very delicate protoplasmic gel.

Finally, the movement of water through the membrane offers an interesting problem. When the osmotic cell is completely surrounded by the solvent, like an enclosed sack, and if the membrane is elastic, one can think of the pressure moving the membrane outward in every direction to include more water, rather than water moving in through the membrane. It is the membrane that moves. But in the living plant osmotic and imbibition forces set up a unilateral movement which has not been satisfactorily explained. The suggestions of Pfeffer as to protoplasmic differences on opposite sides of the cell, and of differences in concentration on opposite sides of the vacuole are too well known to need discussion. Rhythmic pulsations of the osmotically active cells cannot be assumed.

A suggestion which merits attention has recently been made by Loeb. In amphoteric membranes like the protoplasm of root hairs, and of vacuolate cells generally, the opposite sides of the membrane may be oppositely charged. If they were, Loeb points out that positively charged water particles would be driven through the membrane from positive toward negative side, where it would lose its charge after completing passage. The loss of charge allows other positively charged particles to follow; and if a whole series of cells one after the other had such properties, the series would set up a unilateral current of water; in the case of roots let us assume toward the open tracheæ of the vascular system. At least this is one of the possible factors in addition to osmotic pressure

gradients, and might be responsible in part for the removal of water from the cortical cells into the open tracheæ. Electric exosmose has been suggested to account for the glandular secretion of water from cells of high osmotic concentration into ducts with lower concentrations. It can just as easily be a factor in the secretion of water into the tracheæ of roots.

The plant and its whole environment may be looked upon as a system in which atmospheric evaporation is the chief disturber of moisture equilibrium. In response to this disturbance, imbibitional and osmotic forces are set up which reach back from leaves to roots through cohesive water columns. These water columns are fed from below by an active root system which delivers its water by osmotic action and possibly electric transfer of water. The water is imbibed by the hydrophile colloids of the root hairs, from the surface of contiguous soil particles, which in turn exert surface tension, surface, and capillary forces to draw moisture from particle to particle toward the plant. This disturbance finally reaches to the ground water surface, which slowly lowers as the result of this upward movement of water during periods of no precipitation, but is maintained by precipitation from the same atmosphere which, when dry, disturbs the water equilibrium

I am fully aware that there are many points which need investigation before an entirely satisfactory picture of the osmotic phenomena of plant life can be drawn. They are very complex phenomena, perhaps much more complex even than the considerations here brought forward indicate. But with a working hypothesis such as I have briefly outlined, we should be able by appropriate investigations to throw much light on those more or less obscure regions of the problem.

NEW BRITISH CHEMICAL STANDARD STEELS.

(Analytically Standardised Turnings)

Two new plain carbon steels standards are now read for issue, viz., "M", needed for some time mainly for colour carbon tests round about 0·23 per cent, and "0 1" which fills the vacancy for a colour carbon standard of about 0·33 per cent, in addition to being available for the other elements shown below.

The analyses have been undertaken as usual by a number of experienced chemists representing the following interests: British Government Department; U.S. Bureau of Standards; Referee Analysts, independent; Railway Analysts, representing users issuing specifications; Works Analysts, representing makers and users.

The standard figures are as follows:

	"M.	"01."
Carbon	0·228	0·333
Silicon	0·057	0·162
Sulphur	0·05*	0·032
Phosphorus	0·04*	0·031
Manganese	0·6*	0·617
Arsenic	—	0·024
Chromium	—	0·0170
Copper	—	0·037
Nickel	—	0·162

* approximate.

The standards may be obtained either direct from Organising Headquarters, 3, Wilson Street, Middlesbrough; or through any of the leading laboratory furnishers at a price just sufficient to cover the cost. A certificate, giving the names of the analysts co-operating, the types of methods used, and a detailed list of their figures, will be supplied with each bottle.

ILLUSTRATION OF MOLECULAR MOTION.*

By J. NORMAN TAYLOR,
Washington Preparatory School, Y.M.C.A., Washington, D.C.

A proper appreciation by secondary school students of the "habits of Nature," which are expressed in abstract statements called "laws" because of their unfailing truth, is more readily brought about if concrete examples are given to illustrate their application.

For instance, it is very difficult for an immature mind to appreciate the modern theory of the composition of matter. When it is said that matter is not continuous but is of its own nature discrete, *i.e.*, composed of unit particles known as molecules, it is difficult for the student to grasp the full meaning of this abstract statement. His idea regarding the behaviour of these molecules is also a vague one. It is very hard for him to visualise the movements of particles infinitely small, contained in a transparent vessel, and themselves invisible. If he can perform an experiment which will illustrate to him how molecules move very rapidly in straight lines until they collide with each other or come into contact with the walls of the containing vessel, then he will be able to perceive that molecules are elastic. He will also be able to accept the postulate that the interstices between the molecules must of necessity be larger than the molecules themselves. Furthermore, if a student is enabled, through an appropriate illustration, to understand that when heat is applied to the system the molecules move much more rapidly, then he will be in a much better position to take up the study of the gas laws. He will also be enabled to understand more thoroughly the kinetic theory of gases which is based upon all of these considerations.

A device illustrating the assumed behaviour of molecules, and described by E. R. Stoekel in *Science*, xlviii., No. 1245, has been employed by the writer in assisting chemistry students to a better understanding of the molecular theory. It consists essentially of a hard glass tube about 10in. in length and 1in. in diameter, containing a pool of mercury which supports a small quantity of finely crushed material. In using this form of apparatus in the Association School laboratory it has been found that particles of cobalt glass of twenty mesh are very satisfactory. After preparing the tube, as here indicated, it is evacuated so that a pressure of less than a millimeter obtains and is then sealed from the pump. During the subsequent demonstration the tube may be held in the hand without inconvenience, but may, if desired, be clamped to a standard.

Upon the application of heat to the mercury

*Reprinted from June, 1920, issue *School Science and Mathematics*, XX, No. 6.

pool and upon gradually increasing the temperature, the particles on the surface "were carried away by the evaporating mercury" and moved about in the upper part of the tube in much the same manner as gas molecules are presumed to behave.

After completion of the demonstration by the instructor each student may be allowed to verify the experiment. The use of this simple device excellently enables the student to form a clear mental picture of how the very small gas molecules are supposed to be in constant motion, and how the speed of this motion is altered by changes in temperature.

NEW PROCESS FOR THE MANUFACTURE OF SODIUM PERBORATE.

The New York *Journal of Commerce* of April 21 contains an article on an invention which has just been patented by the Norwegian firm Fredrikstad Elektrokemiske Fabriker, for producing sodium perborate, a bleaching powder which has been known and used since the beginning of the 20th century, but which has never been produced in Norway or in Sweden.

The process consists of an electrolysis of common borax in a weak solution. In this way the borax combines with a large percentage of oxygen. One of the disadvantages inherent in the processes utilised hitherto has been that a large percentage of electric energy and borax were wasted. Another disadvantage was that only chemically pure borax could be used, and finally, a third disadvantage consisted in the difficulty of maintaining a continuous and constant production.

Both of these last-named disadvantages have been overcome by adding to the original borax solution a certain amount of sodium cyanide. This addition makes all the impurities harmless, and prevents decomposition of the perborate, which is formed in the solution. Accordingly, it is possible to utilise raw material less pure, and therefore less expensive, thus lowering the cost of production. Continuous production is also made possible.

When the solution is saturated it is poured out and cooled; thereupon a certain amount of sodium superoxide is added which causes a rapid crystallisation of the perborate.

This new bleaching powder has many properties which make it suitable for a number of practical purposes. It is, for instance, a very good antiseptic, and may be used in the treatment of cuts, wounds, &c., both as a powder and dissolved in cold water. It is particularly good as a bleaching agent in the textile industry, and in washing clothes. As a bleaching agent it is absolutely harmless. It may also be used for starching clothes.

FORTHCOMING FAIRS.

Royal Agricultural Show, Derby. June 28-July 3. Includes agricultural machinery and forestry.

London Fair and Market. Royal Agricultural Hall, Islington, July 4-15. Apply to International Trade Exhibitions, Ltd., Broad Street House, New Broad Street, London, E.C.2.

Confectioners' and Bakers' Exhibition. Royal Agricultural Hall, Islington, September 3-9. Apply to 31, Queen Victoria Street, London, E.C.4.

Shipping, Engineering, and Machinery Exhibition. Olympia, September 7-28. Apply to Mr. F. W. Bridges, Exhibition Offices, 36-38, Whitefriars Street, London E.C.4.

Grocers' Exhibition. Royal Agricultural Hall, Islington, September 17-23. Apply to 31, Queen Victoria Street, London, E.C.4.

11th London Medical Exhibition. Central Hall, Westminster, S.W.1, October 3-7. Apply to *British and Colonial Pharmacist*, 194-200, Bishopsgate, London, E.C.2.

International Shoe and Leather Fair. Royal Agricultural Hall, October 3-7. Apply to Manager, *Shoe and Leather Record*, 40, Finsbury Square, London, E.C.2.

Fifth International Commercial Motor Exhibition. Olympia, London, October 14-22. Apply to Exhibition Manager, Society of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, London, S.W.1.

15th International Motor Exhibition. Olympia, and White City, London, November 4-12. Apply to Exhibition Manger, Society of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, London, S.W.1.

7th Cycle and Motor-Cycle Show. Olympia, London, November 28-December 3, 1921. Apply to General Manager, British Cycle and Motor-Cycle Manufactures' and Traders' Union, Ltd., The Towers, Warwick Road, Coventry.

Lemberg, Poland. An Industrial and Agricultural Fair is being arranged in Lemberg, Poland, in September, by the Targi Wschodnie (Eastern Fairs & Markets, Ltd.), of Lemberg, a society organised to promote trade throughout Poland and South Russia. They would like to correspond with any companies interested in East European trade. Exact dates of Fair will be announced later.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, June 9, 1921.

Prof. C. S. Sherrington, President, in the Chair.

The following papers were read :—

"*Break-shock Reflexes and 'Supramaximal' Contraction-response of Mammalian Nerve-muscle to Single-shock Stimuli.*" By Prof. C. S. Sherrington.

The maximal twitch-contraction of tibialis anticus muscle (cat) evoked by a single break-shock applied to the cut motor nerve is compared with the same muscle's contraction as evoked reflexly (spinal preparation) by a single break-shock applied to an afferent nerve. The reflex contraction is found to exceed the former when the break-shock for the former is even considerably weaker than that employed for the latter. Evidence is given that this is due to the reflex response being tetanic in nature. If the break-shock is, however, quite strong (*i.e.*, above the limiting maximal value of Forbes and Gregg) there is evidence

that it excites, even when applied to the motor nerve, a response of tetanic quality. The so-called "over-maximal twitch" is in reality a response of this kind. Such responses are in this paper termed "supra-maximal responses."

Probablitiy is shown that a reaction of like kind obtains in the afferent nerve when the single-shock applied to it is of comparably high value. In this latter case there is added to the tetanic reaction of the spinal centre a tetanic reaction from afferent nerve-fibres themselves. But with weak and moderate break-shock stimuli the seat of origination of the tetanic character of the reflex discharge appears to lie mainly, if not wholly, in the centre itself. It is inferred that it arises there from a process, a "charge" process which is relatively long-lasting in comparison with the cycle of a nerve-impulse, a process which is more intense and of longer duration when the afferent fibres excited are many than when they are fewer.

"Dictyokinesis in Germ Cells, or the Distribution of the Golgi Apparatus during Cell Division." By R. J. Ludford and J. B. Gatenby.

Maturation mitoses in the germ-cells of Cavia, Mus, Helix, Limnæa, and Stenobothrus were examined in order to ascertain the fate of the Golgi apparatus during cell-division.

In all cases the Golgi apparatus is found to separate or break up into its constituent granules or rods, and these are distributed haphazardly to the two daughter-cells at mitosis.

The Golgi apparatus is, in no case examined, divided out between the daughter-cells as carefully and equally as are the chromosomes. This appears to show that from the point of view of a mathematical conception of the hereditary processes, the Golgi apparatus does not share to any important extent, if at all, in the transmission of factors from cell to cell.

"The Effect of Red Fatigue on the White Equation." By F. W. Edridge-Green, M.D.

A white equation is formed by means of a mixture of a red of λ6670–6770 A°, a green of λ5144–5156 A°, and a violet of λ4250–4267 A°, matching a simple white.

When the eye is fatigued with light viewed through a red glass which transmits from λ630μμ to the end of the red end of the spectrum, or with pure spectral light in the region of λ670μμ, and the equation is again made, the amount of green is about half that required for the equation made with the unfatigued eye.

The white equation and its match cannot be due to similar physiological processes, or both would change in the same ratio.

When the fatiguing light is in the region of λ780μμ, no difference is seen between the mixed and simple white.

"A Method for Investigating the Hæmolytic Activity of Chemical Substances." By E. Ponder.

1. A technique for the investigation of the hæmolytic action of chemical substances is described.

2. The relation between the time taken by a given quantity of hæmolytic substance and the temperature at which it acts is expressed by a hyperbola.

3. Equations are given expressing the relation between the constants of such a hyperbola and the quantity of hæmolytic substance to which the hyperbola applies.

4. Certain general relations which have been found to hold for all substances examined in connection with this research are pointed out.

5. A comparison between experimental and calculated results is given.

"The Development of Vegetation in the English Lakes, considered in Relation to the General Evolution of Glacial Lakes and Rock Basins." By W. H. Pearsall.

The data presented show that a very close connection exists between the flora (and fishes) of the English Lakes and the physical and chemical conditions of their shores and waters. These lakes are of the same age (glacial), of similar origin, and lie among rocks possessing relatively uniform characters. It is therefore possible to attribute the differences they show to variations in the rates or errosion and sedimentation of the lake basins, due to inequalities in the durability of the underlying rocks. In distinguishing *rocky* from relatively *silted* lakes, a contrast is therefore made between *primitive* and more highly *evolved* lakes, and it becomes possible to describe the stages in the post-glacial development of a rock basin. The conception has particular value biologically, since it permits the study of the post-glacial development of vegetation. The two extreme phases here distinguished differ in the following particulars:—

	Primitive.	Evolved.
Per cent of drainage system cultivable	5–8	17–45
Per cent of lake shore rocky (to 9 *m.*)	73–47	27–12
Per cent of *Isoetes* and *Nitella*	85–74	52–30
Per cent of *Juncus fluitans*	8–5	2–0
Per cent of *Potamogeton Naias*	½–2	30–55
Phyto-plankton	Desmids dominant	Diatoms dominant
Fish	Chiefly trout.	Chiefly perch and pike.

Evidence is adduced for considering all these differences as ultimately dependent upon the physical condition of the lakes.

CHEMICAL NOTICES FROM FOREIGN SOURCES

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxxii., No. 21.

"Acrylic Acid and Acrylic Ethers. Halogen Derivatives of the propionic Acids and Ethers."—MM. Charles Moureu Marcel Murat, and Louis Tampier.

"Artificial Colouration of Crystals obtained by the Solidification of a Molten Substance, and on Crystalline Diffusion."—M. Paul Gaubert.

"Contribution to the Study of the Oils obtained from Grape Pips."—M. Emile André.

"Application of the Law of Mass Action on the Results obtained in the Reaction of β-galactosidase on Galactose in Propylic Alcohol Solution."

No. 22.

"Double Catalysis of Vanadic Acid and Oxygenated Water."—M. V. Auger.

"On Furfural Camphor and some of its Derivatives."—Mdlle. Wolff.

"Action of Ethylmagnesium Bromide on Dibenzylidene-cyclohexanone and γ-Methyl-cyclohexanone."—M. Manolesco.

"Influence of Ammonium Molybdate on the Rotatory Power of Certain Sugars."—M. Georges Tanret.

NOTES.

FARADAY SOCIETY.—A General Discussion on "Catalysis with Special Reference to Newer Theories of Chemical Action" will take place on September 28 next. During the afternoon session "Radiation Theory" will be discussed, and the opening paper will be given by Prof. J. Perrin (Paris). The evening session will deal with "Heterogeneous Reactions," and it will be opened by Dr. Irving Langmuir (Schenectady, U.S.A.).

THE "SANITAS" COMPANY, LTD.—The General Meeting of the "Sanitas" Company, Ltd., was held at the Cannon Street Hotel, London, E.C.4, on the 15th inst., under the presidency of the Chairman, Mr. C. T. Kingzett, F.I.C., F.C.S., this being the 43rd Annual Meeting held since the incorporation of the original company. The Chairman said it was a matter for congratulation that, notwithstanding the general slump in trade experienced during the year under review, particularly in the export department, and the necessity of writing down stocks acquired at war and boom time high values to current prices, the trade done in the past year had on the whole been satisfactory, sufficing for the payment of the full dividend of 9 per cent on the Preference shares of the Company, and 5 per cent on the Ordinary shares. In view of the great increase in business experienced in the previous year, the Company had acquired and equipped a model factory at Hayes, and were prepared to make use of it as soon as the revival of trade justified the action. "Sanitas Fluid" still held the position of first favourite as the non-poisonous disinfectant and oxidant, devoid of all objectionable qualities, and the sales of that particular article showed a great stride in the year under review. He was also pleased to note improvement in the qualities of the floor polishes, embrocation, and other numerous products of the Company. Their association with Lever Brothers, Ltd., was of the happiest character, and he looked forward to the continued prosperity of the Company's business with full confidence in the competent hands of the Managing Director (Mr. N. F. Kingzett) and his colleagues. The retiring Directors and Auditors were duly re-elected.

DECOMPOSITION OF CHLORACETIC ACIDS.—M. Sanderens has demonstrated by catalysis that organic acids give rise to a cetone with disengagement of carbonic gas. He examined decomposition of the halogen acids, for example $CH_2.Cl.COOH_3$, to ascertain whether symmetric dichloracetone is produced by the action of three different catalysers, thorine, kaolin, and bone-black. With monochloracetic acid, thorine gives a mixture of HCl, CO_2, and CO, with a carbon deposit. Decomposition occurs following the same processes with the other two agents, but in the case of trihalogen acid, whereas thorine and kaolin decompose it into complex products, bone-black transforms it into chloroform with a yield of 85 per cent, the remainder being a mixture of C_2Cl_4 and C_2Cl_6, with a little dissolved hydrochloric acid.—*La Nature*, March 19, 1921.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks, and Designs can be obtained gratuitously.

Latest Patent Applications.

15078—Evershed, H. R.—Process for manufacture of sulphate o lead. May 31.

14986—Farbwerk vorm, Meister Lucius & Bruning.—Manufacture of methylsulphites of secondary aromatic-aliphatic amines. May 30.

15441—Peufaillit, P.—Process for industrially preparing derivatives of bornyl for preparing synthetic camphor. June 3.

15023—Wright, Sir J. R.—Production of ammonium salts and coloured pigments. May 31.

Specifications published this Week.

163877—Phillips, F. J.—Manufacture of readily soluble alkali silicates.

144659—Badische Anilin & Soda Fabric.—Process for transforming ammonia into a salt for use as a fertilizer.

Abstract Published this Week.

Recovering Tin from Scrap.—Mr. P. Mackay of 70, Lombard Street, London, has obtained a Patent No. 161654 for an improved process of recovering tin from Scrap by treating it with oleum to dissolve the tin, the material is then lifted out of the acid and washed in water. Fresh acid is added to replace that used, and another batch is treated. After a time a basic sulphate $Sn\,SO_4$ $Sn\,SO_2$ deposits and is drawn off. The washing water contains some insoluble oxide, SnO_2, and some tin in solution. The dissolved tin is recovered by precipitation as sulphide or iron is added to neutralize the acid and obtain metallic tin. External heat is *not* required in the process, but the acid bath is *maintained* by by the exothermic heat and the periodical additions of fresh acid at a fairly constant temperature of 44-55° C. and a strength of about 10 per cent. free sulphur trioxide.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official *price of 1/- each.*

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by JORDAN & SONS, LIMITED, Company Registration Agents, Chancery Lane, W.C.2.

Public Company.

SWANWICK INSTITUTE & CLUB, LIMITED.—(175051)—Registered 4th June, 1921. The Institute, Pentrich Road, Swanwick. To erect and maintain a Social Club and Institute. Nominal Capital: £2,000 in 4,000 Shares of 10/- each. Minimum Subscription: One-fifth part of the total number of shares offered for subscription. *Directors:* J. Hiel, Wood Dene, Swanwick; G. Elliott (Junior), Hill Crest, Swanwick; G. Harwood, High Street, Swanwick, J. Hopkinson, Church Street, Swanwick; A. Walters, Church Street, Swanwick; R. Marsh (Senior), Derby Road, Swanwick; H. Thompson, Derby Road, Swanwick. Qualification of Directors: £5.

Private Companies:

CHARLES ADAMS & SON, LIMITED.—(175044)—Registered 4th June, 1921. 1c, Queen Square, Bristol. To carry on the business of Corn and Flour Merchants, Millers, etc. Nominal Capital: £100,000 in 10,000 Shares of £10 each. Directors: C. Adams, 11, Apsley Road, Clifton, Bristol; H. C. Adams, Spring Bank, Stonehouse, Gloucestershire; H. Fleetwood, 13, Alexandra Road, Clifton, Bristol. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company in General Meeting.

HORLEY'S, LIMITED.—(175047)—Registered 4th June, 1921. To carry on the business of Capitalists, Financiers, Merchants, etc Nominal Capital: £20,000 in 20,000 Shares of £1 each. Directors: To be appointed by Subscribers. Qualification of Directors: £100. Remuneration of Directors: To be voted by Company in General Meeting. Subscribers: W. Oliver, Madingley, Richmond Bridge, East Twickenham; A. W. Butler, 12a, York Manssions, Battersea Park, S.W.

Brierley & Kershaw, Limited.—(175042)—Registered 4th June, 1921. To acquire and carry on the business of Makers of Flat and Spiral Springs, now carried on at "Roach Spring and Temple Works", Morton Street, Rochdale. Nominal Capital: £20,000 in 20,000 Shares of £1 each. Directors: W. H. Brierley, 83, Southbank Road, Southport: (Governing Director). Qualification of Directors: 1,000 Shares. Remuneration of Directors: To be voted by Company in General Meeting.

Franklin & Ryan, Limited.—(175033)—Registered 3rd June, 1921. 50, Cross Street, Erith, Kent. To carry on the business of Omnibus, Char-a-banc and Cab Proprietors and Haulage Contractors. Nominal Capital: £15,000 in 15,000 Shares of £1 each. Directors: J. G. Franklin, 50, Cross Street, Erith, Kent; C. Ryan, Herbert House, Oaklands Road, Bexley Heath; T. N. Cannon, Mount Eagle, Bexley Heath. Qualification of Directors: 250 Shares. Remuneration of Directors: To be voted by Company in General Meeting.

Wrench, Limited.—(175098)—Registered 7th June, 1921. To acquire and carry on the business of Wholesale, Retail, Manufacturing and Dispensing Chemists and Druggists. Nominal Capital: £1,000 in 500 Preference Shares and 500 Ordinary Shares of £1 each. Directors: C. H. Osmond. Qualification of Directors: £100. Remuneration of Directors: To be voted by Company. Subscribers: F. W. Wrench, 12a, Carlton Road, Bournemouth; Robina S. Osmond, 15, Florence Road, Boscombe.

Kemco, Limited.—(175134)—Registered 9th June, 1921. 36, Trinity Street, Huddersfield. To carry on the business of Pharmacy and Drug Store Proprietors. Nominal Capital: £1,000 in 1,000 Shares of £1 each. Directors: H. Dean, Parkston Grove, Honley, Huddersfield; S. Kenworthy, 157, Trinity Street, Huddersfield. Qualification of Directors: 1 Share.

W. Windle & Co., Limited.—(175146)—Registered 9th June, 1921. 452, Edgware Road, W.2. To carry on the business of Chemists and Druggists. Nominal Capital: £500 in 500 Shares of £1 each. Directors: To be appointed by Subscribers. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company in General Meeting. Subscribers: G. W. Knight, 452, Edgware Road, W.2.; Mabel R. Knight, 452, Edgware Road, W.2.

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Director of Education.

County Education Offices,
Stafford.
June, 1921.

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INDEX.

ABERNETHY, C. L. and W. E. Garner. (*See* Garner, W. E.)
Acid, acrylic, and acrylic ethers, 298
Acid, carbonic, total heat of liquid, 248
Acid, iodic, microchemical reactions, 69
Acid, nitrotartaric, 211
Acid, oxalic, colour test for, 33
Acid, palmitic, properties and molecular structure of thin films of, on water, 214
Acid, silicic, 197
Acid, tartaric, variation in the rotary power of, 202
Acid, vanadic, and oxygenated water, double catalysis of, 298
Acids, chloracetic, catalytic decomposition 167
decomposition 299
Acids, fatty, method and apparatus for routine determination of melting-points of, 130
Acids, glucazone sulphuric, 46
Acidity of coloured solutions, determination, 188
Aconite, colour reaction for, 188
Adam, N. K., properties and molecular structure of thin films of palmitic acid on water, 214
Adriano, Felipe T., volumetric method for the determination of lactose by alkaline potassium permanganate, 157
Africa, South, and South-West, alluvial diamondiferous deposits of, 88, 100, 113
South, diamond-cutting school in, 142
Air imports and exports in 1920, 131
Albuminous substances and saline solutions, intertraction between, 68
Alcohol, amylic, of fermentation, catalytic dehydration, 69
Alcohols, aliphatic, purification and physical properties of certain, 256, 269, 281
catalytic dehydrogenation of, 166
Alkaline earth fluorides, spectra of, and their relation to each other, 258
Alkaloids, vegetable, 82
Allen, E. J., regeneration and reproduction of the Syllid Procerasta, 127
Alsace, potash mines, 95
Aluminium, copper and zinc, constitution of alloys of, containing high percentages of zinc, 117
Ames, John, appointment, 11
Ammonium molybdate, influence on rotatory power of certain sugars, 299
Ammonium persulphate, use for revealing the macrostructure of iron and steel, 69
Analysis, harmonic, apparatus for approximate, 259
principles of, by means of reductive flames, 263
André, Emile, study of the oils obtained from grape pips, 298
Animal tissues, microscopic appearance in ultra-violet light, 235
Ant exterminators, market for, in Colombia, 178
Anthocyanins and anthocyanidins, 127
Apparatus and specimens used in research on the influence of low temperatures on the magnetic properties of alloys of iron with nickel and manganese, 235
British Science Guild Sub-Committee on, 286
Crystallised glass, repair of, 124
for approximate harmonic analysis and for periodicity measurements, 259
for determining hydogen ion concentration, 237
for routine determination of melting-points of fats and fatty acids, 130
Argentine Republic, chemical industry in, 177
Arsenate and arsenite, separation and detection, 230
Arseniates and phosphates, estimation, 11
Arsenic in Queensland, state-owned, 142
Arsenite and arsenate, seperation and detection, 230
Atkinson, H., estimation of potassium in presence of sodium, magnesium, sulphates and phosphates, 237
Atom, constitution of, 289
Atoms, disintegration by α-particles, 169
Atomic energy and radiation from the sun, 219, 277
Auger, V., double catalysis of vanadic acid and oxygenated water, 298
Augite from Nishigatake, Japan, 178
from Vesuvius and Etna, 77, 90
Austin, C. P. and T. M. Lowry. (*See* Lowry, T. M.)
Australia, gem trade with France, 261
tenders invited for, 202
Automatic Furnaces, Limited, 178

B. COLI communis, enzymes of, 127
Back, S. and T. F. Harvey. (*See* Harvey, T. F.)
Baker, J. L. and H. F. E. Hulton, iodimetric determination of the diastatic power of malts, 93
Balance, gravity torsion, 235
Balls, W. L., simple apparatus for approximate harmonic analysis and for periodicity measurements, 259
Barium carbonate, toxicity to rats, 69
Barker, L. N., coal tar for Cairo, 200
Barnard, J. E., microscopic appearance of animal tissues in ultra-violet light, 235
Barnett, E. de Barry, note on the preparation of chloracetyl chloride, 220
Batch materials, relative advantages and disadvantages of limestone, burnt lime and slaked lime as, 57
Batteries, catalogue of primary cells and, 261
Beach, F. F., T. E. Needs and Edward Russell, composition of egg powder, 274
Benzyl alcohol for toothache, 92
Bingham, Kathleen E. and J. L. Haughton. (*See* Haughton, J. L.)
Birmingham University, 82
Blichfeldt, S. H. and T. Thornley method and apparatus for routine determination of melting-points of fats and fatty acids, 130
Board of Trade announcement, 34, 201
Bohler, C. C., artificial resin, 275
Bolland, A., microchemical reactions of iodic acid, 69
Bond, W. N., effect of viscosity on orifice flows, 236
Bone, W. A., researches on brown coals and lignites, 150

Books, Reviews and Notices of—
"British Association of Trade and Technical Journals, Official Handbook," 215
"Chemistry, Physical, A System of," 10
"Chemists, Famous," 94
"Constants, Physical and Chemical, and some Mathematical Functions," 214
"Journal of Indian Industries and Labour," 189
"Paper Makers, Directory of, for 1921," 226
"Pharmacy, Year Book of," 10
"Plants, Introduction to the Study and Reproduction of," 10
"The Yeasts," 10

Borax and saltpetre, 262
Bowen, E. J. and C. N. Hinshelwood. (*See* Hinshelwood, C. N.)
Bowen, I. S., Sir Robert Hadfield and S. R. Williams. (*See* Hadfield, Sir R.)
Bowen, I. S., R. A. Millokan and R. A. Sawyer. (*See* Millokan, R. A.)
Boyer, Sylvester, and Theodore W. Richards. (*See* Richards, T. W.)
Bracken rhizomes and their food value, 5
Bradford Technical College, 131
Bragg, Sir W. H., application of the ionisation spectrometer to the determination of the structure of minute crystals, 187
Intensity of X ray reflection by diamond, 285

Braley, S. A. and F. B. Hobart, new method for the detection and estimation of cobalt, 243
Brazil, high-level diamond deposits of, 39
Briggs, H., adsorption of gas by charcoal, silica and other substances, 214
British Committee for aiding men of letters and science in Russia 9
Engineering Standards Association, 107
Engineers' Association, 250
gas mantle industry, 125
Industries Fair, 34, 80, 141
weights and measures and the metric system, 185
British Science Guild, sub-committee on apparatus, 286
British-American alliance, 201
Bromine, Traces of, 23
Browning, Glen, Irene Everman and O'Neal Mason. (*See* Everman, I.)
Browning, Glen, and William A. Moore. (*See* Moore, W. A.)
Browning, Philip E. and Lyman E. Porter. (*See* Porter, L. E.)
Brunel, Roger, F., J. L. Crenshaw and Elise Tobin, purification and some physical properties of aliphatic alcohols, 256, 269, 281
Bulgaria, tenders for creosote and chloride of lime, 190
Burstall, Prof., possibilities of power production, 154
Burstyn, M. and W. Jakubowicz, action of high temperatures on paraffin, 287
Butter adulteration, detection by means of the melting-point of the insoluble volatile acids, 130
cocoa, detection and estimation of illipé nut fat used as a substitute for, 237

CAIRO, coal tar for, 200

Calcic cyanamide, cyanamide and dicyanamide in, 35
Calcium carbide, tenders invited for, 275
sulphide, variations in conductivity of, due to changes of temperature, 75
Campbell, E. D., a force field dissociation theory of solution applied to some properties of steel, 20
Campbell, N. R., method for the micro-analysis of gases by the use of the Pirani pressure gauge, 285
Camphor growing for Queensland, 239
Capillarity, 117
Carbon, extreme ultra-violet spectrum of, 201
dioxide in coal, determination, 110
monoxide, reversible reactions on iron oxides, 190
steel, overheating high, 178
Carbonic gas, assimilation by green plants, chemical mechanism of, 143
Casmey, W. H., how coal wastage increases tuberculosis, 18
Catalysis, general discussion on, 299
Cattle foods, estimation of woody fibre in, 274
Cavel, M., purification of sewage by the activated sludge process, 47
Cecil, George, the demand for patent medicines in India, 246
Cells and batteries, catalogue of, 261
Chambers, Helen, S. Russ and Gladwys M. Scott. (*See* Russ, S.)
Cheinoff, Lewis H., colour test for oxalic acid, 33
Chemical Society, 118
Chemical elements, relative volumes of, 62, 76
industry in the Argentine Republic, 177
industry in the former Prussian Poland, development of, 33
industry, present position of the fine, 19, 61
nomenclature and pronunciation, 7.
reactions accompanied by pressure, recording by photography, 275
substances, investigating hæmolytic activity of, 298
Chemicals, manufacture of fine, 119
Chemistry, organic, improvement in nomenclature, 122
and chemists, present position of, 208, 221, 232, 250
Chloracetyl chloride, preparation, 220
Chloroform solutions of hydrogen chloride, 62
Chloropicrine, action on germinative faculty of seeds, 131
Chree, C., comparison of magnetic declination changes at British observatories, 117
Ciamician and Ravenna, Messrs., vegetable alkaloids, 82
Clack, B. W., co-efficient of diffusion of certain saturated solutions, 260
Clarke, J. R. Effect of the rays from radium, X rays and ultra- violet light on glass, 274
Coal wastage increases tuberculosis, 18
carbon dioxide in, determination, 110
Coals, brown and lignites, 150
Coal tar for Cairo, 200
Cobalt, chemistry and crystallography of some fluorides of, 27, 43, 52
detection and estimation, 243
Collins, Hawksworth, fundamental constants of nature, 2
relative volumes of chemical elegance, 62, 76
Colombia, market for ant exterminators in, 178
Colour vision, quantum theory of, 223
Comber, Norman M., mechanism of flocculation in soils, 279
Companies, new, 263, 275, 299
Connolly, T. F., handy form of measuring microscope, 141
Cook, Stanley S. and Sir Charles Parsons. (*See* Parsons, Sir C.)
Coolidge radiator tube, pinhole photographs of, 235
Cooper. Hermon C. and Floyd H. Edminster. (*See* Edminster, F. H.)
Copper, action on moulds, 22
aluminium and zinc, constitution of alloys of, containing high percentages of zinc, 117
catalytic activity of, 248
catalytic hydrogenations on, 275
chemistry and crystallography of some fluorides of, 27, 43, 52
Cornell, Fred. C., alluvial diamondiferous deposits of South and South-West Africa, 88, 100, 113
Corrigan, J. Frederick, luminescence in inorganic bodies, 133
storing of light, 25
Corrosion of fireclay refractory materials by glass-making materials, 166
Cotton in the West Indies, 131
Crenshaw, J. L., Roger F. Brunel and Elise Tobin. (*See* Brunel, R. F.)
Crystals, application of the ionisation spectrometer to the determination of the structure of minute, 187
obtained on the solidification of a molten substance, artificial colouration, 298
Crystalline medium, vibrations of, 178
solids, influence of physical conditions on the velocity of decomposition of certain, 213
Currents, Ocean, dissipation of energy in permanent, 165
Thermal transpiration, experiments on, 261
Currie, John, rate of change of glass composition in a tank furnace following a change in the batch composition, 57
Curtman, L. J. and N. H. Hecht, method for the rough estimation of iron and manganese in systematic qualitative analysis, 254
Cyanamide and dicyanamide in calcic cyanamide, 35
Cyanogen, viscosity and molecular dimensions of gaseous, 248

DAMIENS. M., Traces of bromine, 23
Darke, W. F., J. W. McBain and C. S. Salmon, the ultra-microscopic structure of soaps, 93
Datta, S., spectra of the alkaline earth fluorides and their relation to each other, 258
vacuum arc spectra of sodium and potassium, 165
D'Albe, E. E. Fournier, latest form of the optophone, 235
De Grammont, A., spectrum analysis, 58
some technical applications of spectroscopy during the war, 136
De Mallemant, M. R., variation in the rotary power of tartaric acid, 202
De Moræs, Luiz Flores, and T. H. Lee. (*See* Lee, T. H.)
De Retz, M., Alsace potash mines, 95
De Vries, O., properties of rubber, 191
Dehydration, catalytic, of amylic alcohol of fermentation, 69
Dehydrogenation, catalytic, of alcohols, 166
Deniges, M., estimation of phosphates and arseniates, 11
Dennison, D. M., cystal structnre of ice, 54
Desch, Cecil M., physical chemistry of basic slags, 102
Diamond cutting school in South Africa, 142
deposits of Brazil, high-level, 38
ferrazite, a new associate of, 54
overgrowths on, 147, 160, 170
Diamonds, 9
Diamondiferous deposits of South and South-West Africa, alluvial, 88, 100, 113
Diaphragms capable of continuous tuning, design of, 46
Dicyanamide and cyanamide in calcic cyanamide, 35
Diffusion, co-efficient of, of certain saturated solutions, 260
thermal, experiments, 225
Digitalis leaves, 162
Disc, vibrations of a spinning, 224
Disinfectants, tenders for, 286
Distillation, fractional, with contact ring still-heads, 229
Dodd, F. Robertson, estimation of woody fibre in cattle foods, 274
Dolomites, composition, 109
Dowse, G. and E. Meigh, automatic glass feeding devices, 218
Dupree, Sir William, £20,000 for industrial harmony, 22
Dye-stuffs (Import Regulation) Act, 1920, 81, 142

EARTH, cooling of, geologica effects, 259
crust of, superior limit to age of, 150
surface of, transmission of electric waves around, 117
Echinus miliaris, reversal of asymmetry in the plutei of, 150
Economy, people's union for, 22
Eddington, A. S., a generalisation of Weyl's theory of the electro-magnetic and gravitational fields, 149
Edminster, Floyd H. and Hermon C. Cooper, chemistry and crystallography of some fluorides of cobalt, nickel, manganese and copper, 27, 43, 52
Edridge-Green, F. W., effects of red fatigue on the white equation, 298
Egg powder, composition, 274
Egypt, tenders invited for general stores, 262
Einstein's lecture, postponement, 262
theory of gravitation, field of an electron on, 92
Eldrin, a new plant constituent, 138
Electric oscillations along straight lines and solenoids, 284
oscillations, vacuum tubes used as detectors of, 259
resistance, asbolute measurements of, 106
resistivity of dilute metallic solutions, 21
waves, transmission around the earth's surface, 117
Electricity and matter, constitution, 37, 145
Electro-crystalline properties as conditioned by atomic lattices, 149
Electro-magnetic and gravitational fields. Weyl's theory of, 149
Electrolysis and electro-synthesis 193
Electron, field of, on Einstein's theory of gravitation, 92
Elements, spiral classification of, 121
Ellis, C. D., magnetic spectrum of the β-rays excited by the γ-rays, 258
Enamels, lacquers, varnishes, 286
Energy, dissipation in permanent ocean currents, 165
involved in the electric change in muscle and nerve, 223
Enzymes of *B. coli communis*, 127
Eötvös, Baron R., gravity torsion balance, 235
Ethers, acrylic, and acrylic acid, 298
Ethylene, experiments on catalytic reduction to ethane, 248
Ethylmagnesium bromide, action on dibenzylidene-cyclohexanone and γ-methyl-cyclohexanone, 299
Etna, augite from, 77, 90

Everest, A. E. and A. J. Hall, anthocyanins and anthocyanidins, 127
Everman, Irene, O'Neal Mason and Glenn Browning, composition of dolomites, 109
Evers, Norman, calorimetric method of determining hydrogen-ion concentration, 274
Ewing, Sir Alfred, atomic process in ferro-magnetic induction, 258
Exhibition, Canadian National, 190
Daily Mail Efficiency, 70
International Agricultural and Industrial, 287
Printing Trades, 216
Exhibitions, forthcoming, 297
Exports by air in 1920, 131

FARADAY Society, 20, 117, 200, 299
Annual Ceneral Meeting, 21
General discussion on the failure of metals under internal or prolonged stress, 105
Fats and fatty acids, method and apparatus for routine determination of melting-points of, 130
Ferguson, Allan, capillarity, 117
Ferrazite, a new associate of the diamond, 54
Ferric sulphate, manufacture of impure, simultaneous utilsation of pyrites cinders and bisulphates for, 8
Ferro-magnetic induction, atomic process in, 258
Fertiliser experiments, critical study of, 137
Fertilisers, ammoniacal nitrogen in, analysis, 95
Nitrogenous, new method for manufacture, 8
Fertilizing action of sulphur, 131, 142
Fielding, William R., Polymerisation in the solid state, 13
Polymerisation amongst liquids 289
Findlay, Alexander, and Vernon Harcourt Williams, notes on electrolytic reduction of glucose, 145
Finsbury Technical College, 239, 263
Fireclay refractory materials, corrosion by glassmaking materials, 166
Fireclays, British, shrinkage, porosity and density after firing at 1500° C, 273
Firth, Edith N. and W. E. S. Turner, shrinkage, porosity and density of British fireclays after firing at 1500° C, 273
Fishes, flat, asymmetry, metamorphoses and origin of, 224
Flint implement from Selsey Bill, a remarkable, 126
Florentin and Kling, Messrs. (*See* Kling)
Flour and hydrogen peroxide, 34
Fluid motion, stability of, 117
Fluorides, alkaline earth, spectra of, and their relation to each other, 258
of cobalt, nickel, manganese and copper, chemistry and crystallography of, 27, 43, 52
Fluorspar, reflection of the X ray spectrum of palladium from, 285
Focal depth, problem of finite, revealed by seismometers, 248
Food values of bracken rhizomes, 5
Fowler, R. H. and E. A. Milne. (*See* Milne, E. A.)
France, Australian gem trade with, 261
Frederikstad Elektrokemiske Fabriker, new process for the manufacture of sodium perborate, 297
French glass industry, 155
Frequencies, method of measuring, 236
Fritch and Salisbury, Messrs, "Introduction to the Structure and Reproduction of Plants" (review), 10
Froidevant and Vandenberghe, Messrs. Analysis of ammoniacal nitrogen in fertilisers, 95
Fuel economy and national prosperity, 245
oil heaters for linotype machines and similar purposes, 261
Furfural camphor and some of its derivatives, 299

GALACTOSE, reaction of β-galactosidase on, in propylic alcohol solution, application of the law of mass action on the results obtained, 298
Gallium, further studies concerning, 173, 181, 197, 238
Gallium ferrocyanide, use in analysis, 104
Galvanometer records, method of analysing, 225
Gardiner, J. H., new departure in the glass industry, 1
Gardner, H. C. T., spectrometric examination of certain fixed oils as a means of identification, 274
Garner, W. E. and C. L. Abernethy, heats of combustion and formation of nitro-compounds, 165
Gas, adsorption by charcoal, silica and other substances, 214
mantle industry, British, 125
Gases, micro-analysis by use of the Pirani gauge, 285
Gatenby, J. B. and R. J. Ludford (*See* Ludford, R. J.)
Gaubert, Paul, artificial colouration of crystals obtained on the solidification of a molten substance, 298
Germ cells, dictyokinesis in, or the distribution of the Golgi apparatus during cell division 298
Germann, Albert F. O., devitrification of glass, a surface phenomenon, 124
Germany, industrial and economic situation in, 94
Gilmour, George Van B., detection of adulteration in butter by means of the melting-point of the insoluble volatile acids, 130
Glass bottle, action on ink, 130
clouding of, 166
composition, rate of change in a tank furnace following a change in the batch composition, 57
devitrification of, a surface phenomenon, 124
effect of the rays from radium, X-rays and ultra-violet light on, 274
feeding devices, automatic, 218
industry, French, 155
industry, importance of quantitative investigations in dealing with technical problems in, 217
industry, new departure in, 1
making materials, corrosion of fireclay refractory materials by, 166
Glucose, electrolytic reduction of, 145
Glycerin substitute, glycol as, 239
Glycol as a glycerin substitute, 239
Goldsbrough, G. R., influence of satellites upon the form of Saturn's ring, 259
Gravitation, field of an electron on Einstein's theory of, 92
Great Britain, mineral resources of, 83
Grey, E. C. and E. G. Young, enzymes of B. coli communis, 127
Greenwood, George, estimation of phosphorus in phosphor bronze, 225
Griffiths, A. and Constance H. Griffiths, viscosity of water and low rates of shear, 236
Constance H. and A. Griffiths. (*See* Griffiths, A.)
E. A., liquid oxygen vaporiser, 248
Guanol, researches on the action of, 143
Guild, J., refractometry of prisms, 129
Guilliermond, Alexandre, "The Yeasts" (review), 10

H. Is it composed of a whole-number part (A) plus an auxiliary part (B) and a rotating electron (C)?, 8
Hadfield, Sir Robert, K. Onnes and H. R. Woltjer. (*See* Onnes, K.)
Hadfield, Sir Robert, S. R. Williams and I. S. Bowen, magnetic mechanical analysis of manganese steel, 45
Haemolytic activity of chemical substances, investigating, 298
Hall, A. J. and A. E. Everest. (*See* Everest, A. E.)
Hallimond, A. F., the olivine group, 56
Harrison, W. and F. S. Sinnatt. (*See* Sinnatt, F. S.)
Harrogate mineral waters, composition, 94
Hartree, W. and A. V. Hill, method of analysing galvanometer records, 225
Hartshorn, Mr. and E. S. Keeping, notes on vacuum tubes used as detectors of electrical oscillations, 259
Harvey, T. F. and S. Back, estimation of strychnine in scale preparations containing quinine and other cinchona alkaloids, 188
Haughton, J. L. and Kathleen E. Bingham, constitution of the alloys of aluminium, copper and zinc containing high percentages of zinc, 117
Havelock, T. H., stability of fluid motion, 117
Head, Henry, release of function in the nervous system, 234
Health week in 1921, 159
Hebrew University at Jerusalem, 201
Hecht, N. H. and L. J. Curtman. (*See* Curtman, L. J.)
Heliograph mirrors, testing of, and measurement of mirrors of long focal lengths, 238
Hendrick, James, bracken rhizomes and their food value, 5
Herroun, E. F. and E. Wilson, magnetic susceptibility of certain natural and artificial oxides 128
Hill, A. V., energy involved in the electric change in the muscle and nerve, 223
Hill, A. V. and W. Hartree. (*See* Hartree, W.)
Hill, C. A., present position of the fine chemical industry, 19
Hilton, H., vibrations of a crystalline medium, 178
Hinshelwood, C. N. and E. J. Bowen, influence of physical conditions on the velocity of decomposition of certain crystalline solids, 213
Hoaglend, D. R., soil solution in relation to the plant, 265
Hobart, F. B. and S. A. Braley. (*See* Braley, S. A.)
Hodkin, F. W. and W. E. S Turner, relative advantages and disadvantages of limestone, burnt lime and slaked lime as batch materials, 57
Howes, Horace L., luminescence of sammarium, 55
Hulton, H. F. E. and J. L. Baker. (*See* Baker, J. L.)
Humphrey, R. H., note on the hot wire inclinometer, 127
Hutin, M., simultaneous utilisation of pyrites cinders and bisulphates for manufacture of impure ferric sulphate, 8
Hydration, catalytic, of nitriles, 142
Hydrazine, estimation of hypochlorites and chlorates by, 268
Hydrazines, preparation of some, 40
Hydrides, metallic, and the action of hydrogen on the metals, 241
Hydrogen, action on the metals, 241
chloride, chloroform solutions of, 62
ion concentration, apparatus for determining, 327
ion concentration, calorimetric method of determining, 274
peroxide and flour, 34
Hypochlorites and chlorates, estimation by hydrazine, 268

IBBS, T. L., some experiments on thermal diffusion, 225
Ice and water, 249
and water, colour and molecular formula of, 205
crystal structure of, 54
Imports by air in 1920, 131
Inclinometer, hot wire, 127
India, demand for patent medicines in, 246
Indicator, a new, 4
Induction, ferro-magnetic, atomic process in, 258
Industrial harmony, £20,000 for, 22
league, labour and disillusionment, 253
Ink, acidity of, and action of bottle glass on, 130
Institute of Chemistry, annual general meeting, 129
Institute of Metals, 82, 191, 237
Institute of Physics, 169
Institution of Petroleum Technologists, 155
Integrals, transformation of, 117
Interference methods, recent applications of, 179
Interferometer for testing camera lenses, 238
Interrupter, Wehnelt, new form, 225
Iron and Steel Institute, 179, 261
Iron alloys with nickel and manganese, influence of low temperatures on the magnetic properties of, 213, 235
and manganese, estimation in systematic qualitative analysis, 254
and steel, use of ammonium persulphate for revealing the macrostructure of, 69
extreme ultra-violet spectrum of, 201
Iron oxides, reversible re-actions of carbon monoxide on, 190
Italian mercury industry, 287

JABOULAY, E., vanadium in steel, 143
Jackson, Sir Herbert, address to the Institute of Chemistry, 129
Jakubowicz, W. and M. Burstyn. (*See* Burstyn, M.)
Japan, augite from Nishigatake, 178
metric system adopted in, 286
Jeffery, G. B., field of an electron on Einstein's theory of gravitation, 92
Jeffreys, H., certain geological effects of the cooling of the earth, 259
Jenkin, C. F. and D. N. Shorthouse, total heat of liquid carbonic acid, 248
Jerusalem, Hebrew University at, 201
Jolibois, P., recording chemical reactions accompanied by pressure, by photography, 275
Joly, J., quantum theory of colour vision, 223

KAS, Nemec and Varchav, action of selenium on moulds, 22
Kaye, G. W. C. and T. H. Laby, "Physical and Chemical Constants and some Mathematical Functions" (review), 214
Keeping, E. S. and Mr. Hartshorn (*See* Hartshorn, Mr.)
Kendall, James, molecular state of water vapour, 30
King, L. V., design of diaphragms capable of continuous tuning, 46
Kinkhead, R. W., new indicator, 4
Kitching, A. F., glucosazone sulphuric acids, 46
Kling and Florentin, Messrs., properties and constitution of the group $OCCl_3$, 83
Knor, M., practical methods employed in the stearine industry, 262
Kubota, Bennosuke, and Paul Sabatier. (*See* Sabatier, P.)
Kyle, H. M., asymmetry, metamorphosis and origin of flat-fishes, 224

LABOUR and disillusionment, 253
Laby, T. H. and G. W. C. Kaye. (*See* Kaye, G. W. C.)
Lachman, Arthur, nitrotartaric acid, 211
Lacquers, enamels, varnishes, 286
Lactose determination, volumetric method by alkaline potassium permanganate, 157
Lakes and varnishes, tetraline in manufacture of, 131
Lamb, H. and R. V. Southwell, vibrations of a spinning disc. 224
Lankester, Sir E. Ray, remarkable flint implement from Selsey Bill, 126
Lantos, E., congealing point of mineral oils, 262
Larmor, Sir Joseph, electrocrystalline properties as conditioned by atomic lattices, 149
Lattices, atomic, electro-crystalline properties as conditioned by, 149
LaWall, Charles H., an epochmaking discovery, 139
Le Bas, Gervaise, theory of molecular refractions, 194
water and ice, 249
Lead, action of water on, 188
allotropic form of, 239
helogen, derivatives of, 22
Lee, T. H. and Luiz Flores De Moraes, ferrazite, a new associate of the diamond, 54
Lenher, Victor, preparation of selenium oxychloride, 40
silicic acid, 197
Lenses, camera, interferometer for testing, 238
Lessing, R., fractional distillation with contact ring still-heads, 229
Lewis, William C. McM., "System of Physical Chemistry" (review), 10
Light, absorption by electrically luminescent mercury vapour, 214
from the night sky, colour of, 165
storing of, 25
Lignites and brown coals, 150
Linear transformations and functions of positive type, 93
Linhart, G. A. and C. B. Lipman. (*See* Lipman, C. B.)
Linoleum, revival in manufacture of, 202
Lipman, C. B. and G. A. Linhart, critical study of fertilizer experiments, 137
Liquids, polymerisation amongst, 289
Lizius, J. L., method for the determination of the acidity of coloured solutions, 188
Lloyd, J. T., spiders used in medicine, 163
Lloyd, John Uri, eldrin, a new plant constituent, 138
Loring, F. H., atomic energy and radiation from the sun, 219
atomic energy and radiation: sunspots and aurora, 277
disintegration of atoms by α particles, 169
is H composed of a whole-number part (A) plus an auxiliary part (B) and a rotating electron (C)? 8
Lowry, T. M. and C. P. Austin, optical rotatory dispersion, 284
Lowson, William, composition of Harrogate mineral waters, 94
Ludford, R. J. and J. B. Gatenby, dictyokinesis in germ cells, or the distribution of the Golgi apparatus during cell division, 298
Luminescence in inorganic bodies, 133

McBAIN, J. W., W. F. Darke, and C. S. Salmon. (*See* Darke, W. F.)
MacBeth, Alexander Killen, estimation of hypochlorites and chlorates by hydrazine, 268
Macdonald, H. M., transmission of electric waves around the earth's surface, 117
Macht, David I. Benzyl alcohol for toothache, 92
Magnetic declination changes at British observatories, comparison between, 117
Magneton, anhydrous sulphates and the theory of, 47
Malts, iodimetric determination of the diastatic power of, 93
Manchester Literary and Philosophical Society, 117
annual general meeting, 249
Manganese, alloys of iron with, influence of low temperatures on the magnetic properties of 213, 235
and iron, estimation in systematic qualitative analysis, 254
chemistry and crystallography of some fluorides of, 27, 43, 52
Manganese in presence of iron or other substances, rescareh for traces, 263
Manganese steel, magnetic mechanical analysis of, 45
Manolesco, M., action of ethylmagnesium bromide on dibenzylidene-cyclohexanone and γ-methyl-cyclohexanone, 299
Manures, chemical, in Spain, price of nitrogen unit of, 142
cheap, for the farmer, 167
Marion, M., hydrogen peroxide and flour, 34
Mason, O'Neal, Irene Everman, and Glenn Browning. (*See* Everman, I.)
Matter and electricity, constitution, 37, 145
Mayer, Henry, bequest, 263
Maze, M., chemical mechanism of the assimilation of carbonic gas by green plants, 143
Medicine, spiders used in, 163
Medicines, patent, demand in India, 246
Meigh, E., and G. Dowse. (*See* Dowse, G.)
Mellaneh, S., colour reaction for aconite, 188
Mercer, J., linear transformations and functions of positive type, 93
Mercury industry, Italian, 287
Merton, T. R., spectrophotometry in the visible and ultra-violet spectrum, 150
Merwin, H. E., and Henry S. Washington (*See* Washington, H. S.)
Metals, casting of, 202, 237
failure under internal or prolonged stress, 105, 154
in saline solutions, displace of, 262
Metallic solutions, electrical resistivity of dilute, 21
Metcalfe, E. P. and B. Venkatesachar, absorption of light by electrically luminescent mercury vapour, 214
Meteorites, Adare and Enshisheim chemical composition, 178
Metric system, British weights and measures and, 185
system adopted in Japan, 286
Meunier, M. I., principles of analysis by means of reductive flames, 263
Mexico, candelilla wax in, 11
Michelson, A. A., some recent applications of interference methods, 179
Microphone, a selective hot-wire, 45
Microphotometer, a new registering, 186
Microscope, measuring, 141
Miège, M. E., action of chloropicrine on the germinative faculty of seeds, 131
Millokan, R. A., I. S. Bowen and R. A. Sawyer, extreme ultraviolet spectrum of carbon, iron and nickel, 201
Milne, E. A. and R. H. Fowler, siren harmonics and a pure-tone siren, 46
Mineral resources of Great Britain, 83
waters of Harrogate, composition, 94
Mineralogical Society, 56, 178
Mirrors, heliograph, testing, and measurement of mirrors of long focal lengths, 238
Mitchell, C. Ainsworth, acidity of ink and the action of bottle glass on ink, 130
Molecular motion, illustration of, 296
refractions, theory of, 194
Moll, J. H., a new registering microphotometer, 186
Molybdenum, to detect the presence of, 95
Moore, William A. and Glen Browning, substances dissolved in rain and snow, 51
Moureu, Charles, Marcel Murat and Louis Tampier, acrylic acid and acrylic ethers, 298
Muller, M., new method for colorimetric analysis of small quantities of uranium, 83
Murat, Marcel, Charles Moureu and Louis Tampier. (*See* Moureu, C.)
Muscle and nerve, energy involved in the electric change in, 223
Myogram of the flexor-reflex evoked by a single breakshock, 68

NATURE, fundamental constants of, 2
Needs, T. E., F. F. Beach and Edward Russell. (*See* Beach, F. F.)
Nerve-muscle, mammalian, break-shock reflexes and supramaximal contraction-response ot, to single-shock stimuli, 297
Nervous system, release of function in, 234
New Explosives Company, lacquers, enamels, varnishes, 286
Newall, H. F., the story of a new star, 141
Newman, F. H., new form of Wehnelt interrupter, 225
Nickel, alloys of iron with, influence of low temperatures on the magnetic properties of, 213, 235
chemistry and crystallography of some fluorides of, 27, 43, 52
extreme ultra-violet spectrum of, 201
Nicolas, M., fertilizing action of sulphur, 131
Nitre cake, methods of complete recovery of, 229
Nitriles, catalytic hydration, 142
Nitro-compounds, heats of combustion and formation, 165
Nitrogen, ammoniacal, in fertilisers, analysis, 95
unit in chemical manures in Spain, price of, 142
Nomenclature of organic chemistry, improvement in, 122
Norbury, A. L., electrical resistivity of dilute metallic solutions, 21
Norris, W. H. H., methods for the complete recovery of nitre cake, 229
Notes and queries, recovering tin from tin scrap, 239

OATS, oil of, 237
Obituary. Odling, William, 118
$OCCl_3$, properties and constitution of the group, 83
Odling, William, obituary, 118
Ohshima, H., reversal of asymmetry in the Plutei of Echinus miliaris, 150
Oil, linseed, substitutes, 35
of oats, 237
Oils, mineral, congealing point of, 262
obtained from grape pips, study of, 298
spectrometric examination of certain fixed, as a means of identification, 274
Olivine group, 56

Onnes, K., Sir R. Hadfield and H. R. Woltjer, apparatus and specimens used in research on the influence of low temperatures on the magnetic properties of alloys of iron with nickel and manganese, 235
influence of low temperatures on the magnetic properties of alloys of iron with nickel and manganese, 213
Optical Society, 141, 238
rotatory dispersion, 284
Optophone, 235
Orifice flows, effect of viscosity on, 236
Osmotic phenomena, 293
Ossa, B. Diaz, borax and saltpetre, 262
Oxides, cuprous, by reduction, 99
magnetic susceptibility of certain natural and artificial, 128
Oxley, A. E., a force field dissociation theory of solution applied to some properties of steel, 20
Oxygen, liquid, vaporiser, 248
Oxygenated water and vanadic acid, double catalysis of, 298

PALLADIUM, reflection of the X ray spectrum of, from fluorspar, 285
Palmer, Dorothy M., and W. G. Palmer, some experiments on the catalytic reduction of ethylene to ethane, 248
Palmer, W. G., catalytic activity of copper, 248
Paraffin, action of high temperatures on, 287
Paramolybdates, constitution of, 81
Paris, E. T., and W. S. Tucker. (*See* Tucker, W. S.)
Parry, Hubert, balance method of using the quadrant electrometer for the measurement of power, 187
Parsons, Sir Charles, and Stanley S. Cook, attempt to reach high instantaneous pressure by the collapse of a hollow sphere of lead under external pressure suddenly applied by explosive, 235
Partridge, G. F., and B. S. Smith. (*See* Smith, B. S.)
Patents, new, 11, 23, 35, 47, 70, 83, 95, 107, 143, 155, 167, 179, 191, 202, 216, 226, 239, 250, 263, 275, 288, 299
Patterson, T. S., The Chemical Society, 118
Paul, Ernest, note on the oil of oats, 237
Pealing, H., reflection of the X ray spectrum of palladium from fluorspar, 285
Pearsall, W. H., development of vegetation in the English Lakes, 298
Periodicity measurements, apparatus for, 259
Perphosphates and their industrial application, 116
Phosphates and arseniates, estimation, 11
Phosphorus in phosphor bronze, estimation, 225
Physical Society, 127, 186, 236, 259, 285
annual general meeting, 106
Pilcher, Richard B., Dyestuffs (Import Regulation) Act, 1920, 81
Plants, chemical mechanism of the assimilation of carbonic gas by green, 143
cytology of the Statolith apparatus in, viewed in relation to their habit and biological requirements, 224
Plants, soil solution in relation to, 265
Poland, development of the chemical industry in the former Prussian, 33
Polymerisation amongst liquids, 289
in the solid state, 13
Polymolybdates, tetrabasic, 82
Ponder, E., method for investigating the hæmolytic activity of chemical substances, 298
Pontie, A. M., notes on the high-level diamond deposits of Brazil, 38
Pooley, John W. and Francis C. H. Tate. (*See* Tate, F. C. H.)
Porter, Alfred W., some aspects of the scientific work of the late Lord Rayleigh, 200
Porter, Lyman E. and Philip E. Browning, use of gallium ferrocyanide in analysis, 104
Posternak, M. S., constitution of the paramolybdates, 81
tetrabasic polymolybdates, 82
Potash mines of Alsace, 95
Potassium and sodium, vacuum arc spectra of, 165
estimation in presence of sodium, magnesium, sulphates and phosphates, 237
Potatoes, export of seed, 11
Power, Frederick Belding, presentation to, 272
Power, measurement, balance method of using the quadrant electrometer for, 187
production, possibilities of, 154
Prankerd, T. L., studies in the cytology of the Statolith apparatus in plants, viewed in relation to their habit and biological requirements, 224
Pressure, high instantaneous, attempt to reach, 235
Prior, G. T., chemical composition of the Adare and Ensisheim meteorites, 178
Prisms, refractometry of, 129

QHASHI, R., augite from Nishigatake, Japan, 178
Queensland, camphor growing for, 239
State-owned arsenic in, 142
Quinine and other cinchona alkaloids, estimation of strychnine in scale preparations containing, 188

RADIUM and X rays, local and generalised action on tumour growth, 68
Rain and snow, substances dissolved in, 51
Rankine, A. O., viscosity and molecular dimensions of gaseous cyanogen, 248
Rat poison, extract of red squill (Scilla maritima) as, 94
Rats, toxicity of barium carbonate to, 69
Ravenna and Ciamician, Messrs. (*See* Ciamician)
Rays, tracing through an optical system, 129
β-Rays, magnetic spectrum of, excited by the γ-rays, 258
Rayleigh, Lord, colour of the light from the night sky, 165
some aspects of the scientific work of the late, 200
Red fatigue, effect on the white equation, 298
Refractions, molecular, theory of, 194
Refractometry of prisms, 129
Relativity, an epoch-making discovery, 139
Relativity, theory of, 81, 250
Research, department of scientific and industrial, 131
value of scientific, 67
Resin, artificial, 275
Resins and varnishes, synthetic, 239
Rhizomes, bracken, and their food value, 5
Rhodes, H. T. F., Srivastra's hypothesis, 145
theory of auxiliary valencies and water of crystallisation, 85, 97
Richards, Theodore W., and Sylvester Boyer, further studies concerning gallium, 173, 181, 197
Richardson, W. A., method of rock-analysis diagrams based on statistics, 57
Rideal, E. K., catalytic dehydrogenation of alcohols, 166
Riga, International Agricultural and Industrial Exhibition, 287
Roberts, G. H., labour and disillusionment, 253
Robertson, R., salary of chemists, 250
Rock-analysis diagrams based on statistics, 57
Roscoe, John, primitive races in Uganda, 235
Rosenhain, W., hardness of solid solutions, 225
Rothamsted Experiment Station, 247
Royal Institution, 22, 39, 70, 82, 87, 130, 154, 178, 193, 215, 226, 250, 274
Royal Society, 45, 68, 87, 92, 117, 126, 149, 165, 178, 213, 223, 234, 248, 258, 284, 297
conversazione, 235
Rubber, properties of, 191
Russ, S., Helen Chambers and Gladwys M. Scott, local and generalised action of radium and X rays upon tumour growth, 68
Russell, Edward, F. F. Beach, and T. E. Needs. (*See* Beach, F. F.)
Russell, E. J., utilisation of basic slag, 73
Russell, H. N., superior limit to the age of the earth's crust, 150
Russia, British Committee for aiding men of letters and science in, 9

SABATIER, Paul, and Bennosuke Kubota, catalytic hydrogenations on copper, 275
Saccharose preparations, very active, 191
Saha, M. N., a physical theory of stellar spectra, 92
Saline solutions and albuminous substances, intertraction between, 68
solutions, displacement of metals in, 26
Salisbury and Fritch. (*See* Fritch)
Salmon, C. S., W. F. Darke and J. W. McBain. (*See* Darke, W. F.)
Saltpetre and borax, 262
Samarium, luminescence of, 55
Sanderens, M., decomposition of chloracetic acids, 299
Sanitas Company, Limited, 299
Sarma, V. V., cuprous oxides by reduction, 99
Sassa, K. and C. S. Sherrington, myogram of the flexor-reflex evoked by a single break-shock, 68
Saturn's ring, influence of satellites upon the form of, 259
Sawyer, R. A., R. A. Millokan and I. S. Bowen. (*See* Millokan, R. A.)
Science, problems of modern, 83
Scott, Gladwys M., S. Russ and Helen Chambers. (*See* Russ, S.)
Sears, George W., separation and detection of arsenate and arsenite, 230
Seeds, action of chloropicrin on germinative faculty of, 131
Seisometers, problem of finite focal depth revealed by, 248
Selenium, action on moulds, 22
Selenium oxychloride, preparation, 40
Selsey Bill, a remarkable flint implement from, 126
Senderens, J. B., catalytic dehydration of amylic alcohol of fermentation, 69
Sewage purification by the activated sludge process, 47
Shackleton, W., testing of heliograph mirrors and the measurement of mirrors of long focal lengths, 238
Sheep's teeth, dental incrustations and the so-called gold-plating of, 49
Sherrington, C. S., break-neck reflexes and supramaximal contraction-response of mammalian nerve-muscle to single-shock stimuli, 297
Sherrington, C. S. and K. Sassa. (*See* Sassa, K.)
Shorthouse, D. N. and C. F. Jenkin. (*See* Jenkin, C. F.)
Shull, Charles A., osmotic phenomena, 293
Siemens Bros. and Co., Limited, catalogue of primary cells and batteries, 261
Sinnatt, F. S. and W. Harrison, determination of the carbon dioxide in coal, 110
Sir John Cass Technical Institute, 94, 141
Siren harmonics and a pure-tone siren, 46
Sky, colour of the light from the night, 165
Slag, utilisation of basic, 73
Slags, physical chemistry of basic, 102
Smetham, Alfred, address to the Society of Public Analysts 150
Smith, B. S. and G. F. Partridge, method of measuring frequencies, 236
Smith, F. W., extract of red squill (Scilla maritama) as a rat poison, 94
Smith, T., tracing rays through an optical system, 129
Snow and rain, substances dissolved in, 51
Soaps, ultra-microscopic structure of, 93
Societies, scientific, conjoint board of, 190, 274
Society of Glass Technology, 57, 166, 273
annual general meeting, 217
Society of Leather Trades Chemists, 120
Society of Public Analysts, 93, 130, 188, 237, 274
annual general meeting, 150
Sodium and potassium, vacuum arc spectra of, 165
Sodium perborate, new process for manufacture, 297
Soil, physico-chemical problems relating to, 215
solution in relation to the plant, 265
Soils, mechanism of flocculation in, 279
Solution, force field dissociation theory of, applied to some properties of steel, 20
Solutions, coloured, determination of acidity of, 188

Solutions, solid, hardness of, 225
Southwell, R. V. and H. Lamb. (*See* Lamb, H.)
Spain, price of the unit of nitrogen in chemical manures in, 142
Spectra, magnetic, photographs by M. le Duc de Broglie, 285
of alkaline earth fluorides and their relation to each other, 258
stellar, physical theory of, 92
vacuum arc, of sodium and potassium, 165
Spectrum analysis, 58
extreme ultra-violet of carbon, iron and nickel, 201
magnetic, of β-rays excited by the γ-rays, 258
spectrophotometry in the visible and ultra-violet, 150
X ray, of palladium from fluorspar, reflection of, 285
Spectrophotometry in the visible and ultra-violet spectrum, 150
Spectroscopy, technical applications during the war, 136
Spencer, L. J., identity of Trechmann's tin with stannous sulphide, 57
Spiders used in medicine, 163
Squill, extract of red, as a rat poison, 94
Srivastra, A. N., constitution of matter and electricity, 37, 145
Stannous sulphide, identity of Trechmann's tin with, 57
Star, the story of a new, 141
Stearine industry, practical methods employed in, 262
Steel, Thomas, dental incrustations and the so-called gold-plating of sheep's teeth, 49
diamonds, 9
Steel and iron, use of ammonium persulphate for revealing the macrostructure of, 69
force field dissociation theory of solution applied to some properties of, 20
vanadium in, 143
Steels, new British chemical standard, 296
Stellar spectra, physical theory of, 92
Street, R. O., dissipation of energy in permanent ocean currents, 165
Strychnine in scale preparations containing quinine and other cinchone alkaloids, estimation, 188
Sugars, influence of ammonium molybdate on rotatory power of, 299
Sulphates, anhydrous, and the theory of the magneton, 47
Sulphur, fertilizing action of, 131, 142
Sun, atomic energy and radiation from, 219
spots and aurora, 277
Superphosphate manufacture, new process, 131
Sutton, J. R., overgrowths on diamond, 147, 160, 170
Swain, E. H. F., camphor growing for Queensland, 239
Syllid procerasta, regeneration and reproduction, 127

TAMPIER, Louis, Charles Moureu and Marcel Murat, (*See* Moureu, C.)
Tank furnace practice, problems arising in, through shortage of saltcake, 57
Tanner, F. W., "The Yeasts" (review), 10
Tanret, Georges, influence of ammonium molybdate on rotatory power of certain sugars, 299
Tansley, L. Beaumont, spiral classification of the elements, 121
Tate, Francis C. H. and John W. Pooley, detection and estimation of Illipe nut fat used as a substitute for cocoa butter, 237
Taxation, commercial motor, 11
Taylor, J. Norman, chemical nomenclature and pronunciation, 7
illustration of molecular motion 296
Tetraline in manufacture of lakes and varnishes, 131
Thallium, halogen derivatives of, 22
Theodorides, M., anhydrous sulphates and the theory of the magneton, 47
Thermal diffusion, experiments on, 225
Thiel, A., pretended allotropic form of lead, 239
Thompson, Leonard, preparation of some hydrazines, 40
Thomson, Sir J. J., constitution of the atom, 289
Thornley, T. and S. H. Blichfeldt. (*See* Blichfeldt, S. H.)
Thorsell, Mr., new method for manufacture of nitrogenous fertilisers, 8
Thresh, J. C., action of water on lead, 188
Tobin, Elise, Roger F. Brunel and J. L. Crenshaw. (*See* Brunel, R. F.)
Tomkinson, Eric, colour of water, 9, 22, 34
colour and molecular formula of water and ice, 205
gallium, 238
metallic hydrides and the action of hydrogen on the metals, 241
Toothache, benzyl alcohol for, 92
Townsend, J. S., electric oscillations along straight lines and solenoids, 284
Travers, Morris W., clouding of glass, 166
importance of quantitative investigation in dealing with technical problems in the glass industry, 217
Trechmann's tin, indentity with stannous sulphide, 57
Tuberculosis, coal wastage increases, 18
Tucker, W. S., and E. T. Paris, a selective hot-wire microphone, 45
Tumour growth, local and generalised action of radium and X rays upon, 68
Turner, Donald, and W. E. S. Turner, note on the corrosion of fireclay refractory materials by glassmaking materials, 166
Turner, Thomas, casting of metals, 202, 237
Turner, W. E. S., problems arising in tank furnace practice through shortage of saltcake, 57
Turner, W. E. S., and F. W. Hodkin. (*See* Hodkin, F. W.)
and Edith N. Firth. (*See* Firth, E. N.)
and Donald Turner. (*See* Turner, D.)
Twyman, F., interferometer for testing camera lenses, 238

UGANDA, primitive races in, 235
Uranium, colorimetric analysis of small quantities, new method, 83

VACUUM tubes used as detectors of electrical oscillations, 259
Vaillant, M., variations in the conductivity of calcium sulphide due to changes of temperature, 75
Valencies, auxiliary, theory of, and water of crystallisation, 85, 97
Vanadium in steel, 143
Vandenberghe and Froidevant, Messrs. (*See* Froidevant)
Varnishes and lakes, tetraline in manufacture of, 131
and resins, synthetic, 239
lacquers, enamels, 286
Vegetation in the English Lakes, development of, 298
Venkatesachar, B., and E. P. Metcalfe. (*See* Metcalfe, E. P.)
Vesuvius, augite from, 77, 90
Vibrations of a crystalline medium, 178
of a spinning disc, 224
Villedieu, M. and Mme., action of copper on moulds, 22
Viscosity, effect on orifice flows, 236

WALKER, G. W., problem of finite focal depth revealed by seismometers, 248
Walker, Sir James, electrolysis and electro-synthesis, 193
Washington, Henry S. and H. E. Merwin, note on augite from Vesuvius and Etna, 77, 90
Water, action on lead, 188
action on wool, 105
and ice, 249
and ice, colour and molecular formula of, 205
colour of, 9, 22, 34
Water of crystallisation, theory of auxiliary valencies and, 85, 97
vapour, molecular state of, 30
viscosity and low rates of shear, 236
Wax, candelilla, in Mexico, 11
Wehnelt interrupter, new form, 225
Weights and measures, British, and the metric system, 185
West, G. D., experiment on thermal transpiration currents, 261
West Indies, cotton in, 131
Weyl's theory of the electromagnetic and gravitational fields, 149
Wheat pests problem, 67
Wheeler, T. Sherlock, an improvement in the nomenclature of organic chemistry, 122
White equation, effects of red fatigue on, 298
Williams, E. J., chloroform solutions of hydrogen chloride, 62
Williams, G. W. Monier, notes and demonstration on apparatus for determining hydrogen ion concentration, 237
Williams, S. R., Sir Robert Hadfield and I. S. Bowen. (*See* Hadfield, Sir R.)
Williams, Vernon Harcourt, and Alexander Findlay. (*See* Findlay, A.)
Wilsmore, N. T. M., present position of chemistry and chemists, 208, 221, 232
Wilson, E. and E. F. Herroun. (*See* Herroun, E. F.)
Wolff, Mdlle., furfural camphor and some of its derivatives, 299
Woltjer, H. R., K. Onnes and Sir Robert Hadfield. (*See* Onnes, K.)
Wool, action of water on, 105
Wright, Sir Almroth, intertraction between albuminous substances and saline solutions, 68

X RAY examination of materials, photographs illustrating protection in, 235
reflection, intensity by diamond, 285
spectrum of palladium from fluorspar, reflection of, 285
X rays and radium, local and generalised action upon tumour growth, 68

YOUNG, E. G., and E. C. Grey. (*See* Grey, E. C.)
Young, W. H., transformation of integrals, 117

ZINC, aluminium and copper, constitution of alloys of, containing high percentages of zinc, 117

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